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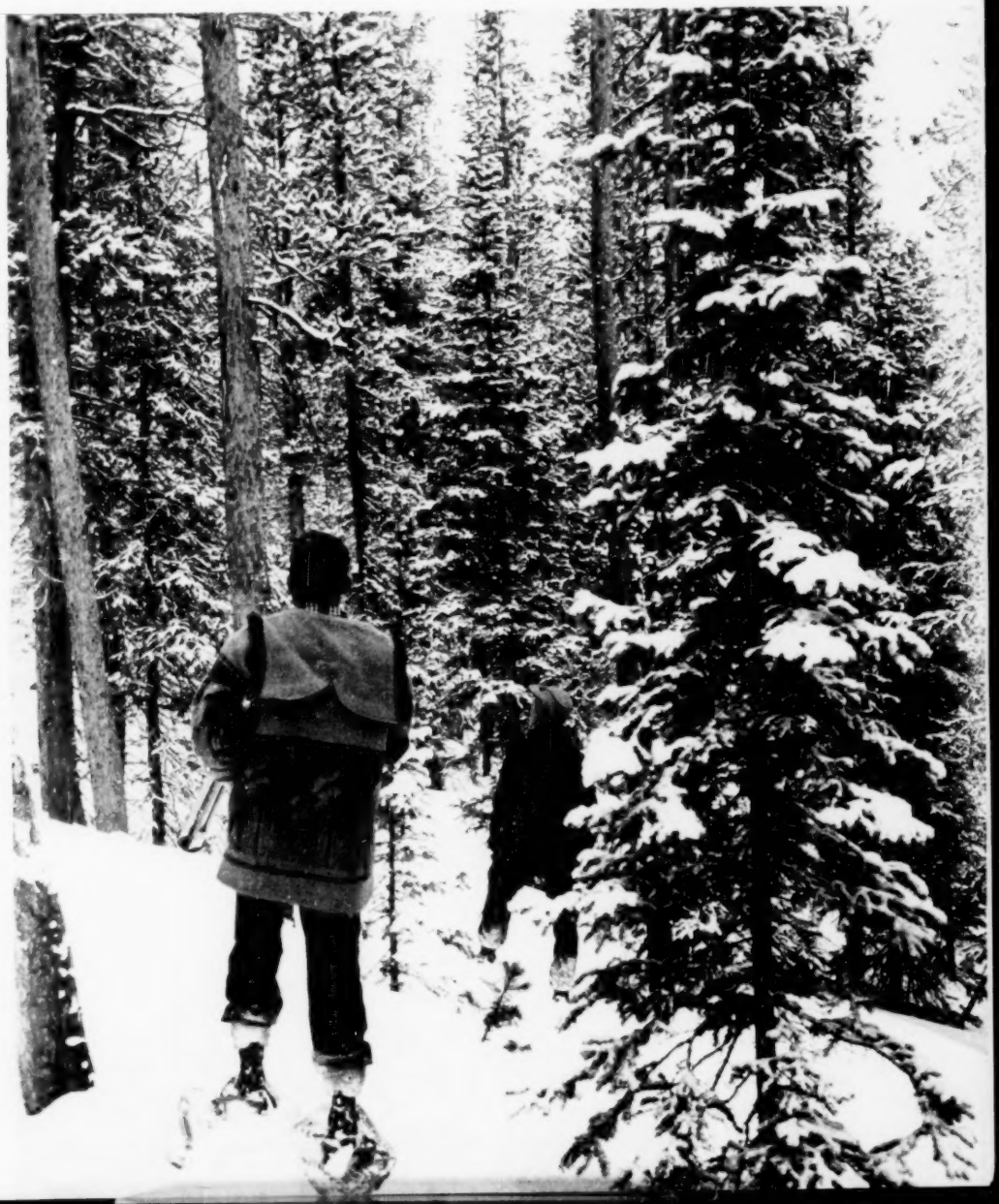

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Journal of Forestry

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Forest Management for More and Better Water

Leon Lassen
and Bernard Frank

Respectively, hydrologic engineer and forester, Division of Forest Influences, U. S. Forest Service, Washington, D. C.

THE HANDLING of forest lands for the production of better and greater supplies of water has long been a goal of watershed management. The limited research to date in this field has already produced significant results. Findings of even greater significance may be expected in the future under the stimulus of an active public interest in the full development and utilization of the nation's water resources.

The desirability of knowing when and under what specific conditions forest lands can be made to yield more water for consumptive purposes has become of considerable practical value. The demand for water is urgent. It is an articulate demand, backed by the large financial resources of government and private industry. Billions are being spent to store it, convey it, treat it, (to suit requirements) and conserve it.

Acre for acre, more water falls on forest land than anywhere else. Acre for acre, in many well forested areas containing valuable timber species — in the humid east as well as the west — the annual value of water actually utilized for domestic or industrial purposes exceeds the stumpage value of the annual timber cut. And this holds just as well for private as for public lands.

So far, the attention given to the watershed aspects of forest management has centered — rightly enough — on the repair of damaged areas in order to control harmful runoff and erosion. Since CCC days, the great bulk of this work has continued to be undertaken on federal lands. In more recent years there has also developed a greater appreciation of the need for taking a second step: namely, the promotion of forest grazing and timber harvesting practices which will avoid unnecessary damage and hence reduce losses of soil and water.

Foresters, as managers or consultants on both public and private timber holdings, are today helping achieve the protection and improvement of the soil as well as its plant cover. One reason for this is that they are rapidly coming to realize the advantages of encouraging the development of healthy soil conditions for the sake of faster and healthier timber growth. The resulting improvements in timber growing and harvesting practices that are bound to come about will be reflected in a corresponding gain in watershed protection values also.

Now the way is being paved for the third step, namely, the deliberate planning of timber cutting practices to increase the yield of useful water for domestic, agricultural, industrial, and recreational purposes. Although the strongest direct pressure for water resource management today is on public lands, private lands cannot very well be overlooked, especially since most of the forested water sources over the nation as a whole are in private ownership.

Many advantages may be expected from adding the production of better and larger water yields to the objectives of private forest management. As demands for satisfactory water supplies increase, public pressures to meet them will inevitably grow stronger. Private lands will be expected to help carry the load. The fact that no industry today would think of expanding without first checking on available water supplies is a good index of future trends in this direction. For example, no pulp mill would think of locating in an area without investigating the water supply situation, regardless of the abundance of labor and raw materials. In some instances industrial firms have gone so far as to purchase watershed areas to assure themselves of satisfactory water sources. In other instances municipalities or water districts are actively abetting the adoption of improved forestry practices on private holdings in the water source areas for the same reason.

Protecting watersheds is one thing. Deliberately managing them for better and greater water supplies is another. How can foresters go about meeting this second requirement? First and foremost must come a practical understanding of the basic relations of forests and water.

Basic Concepts

In an article in the JOURNAL OF FORESTRY, Dr. Charles R. Hursh outlined the basic concepts of forest hydrology and discussed some of the more important characteristics of water flow with which the forest manager should become acquainted. He compared the knowledge needed to develop and manage the water resource with that needed for timber management. This included a working understanding of climatology, hydrology, and soil, and the effects of land management on the water balance. Thus water management, as with timber, requires an "in-

ventory" of the capabilities of different portions of an area to "produce" water, a knowledge of the characteristics of water production, including the periods of maximum and minimum water yields, and an awareness of the "markets" for the product (municipal, industrial recreation, hydroelectric power, etc.) (4).

That the practicing "dirt" forester should know his soils, goes without saying. A knowledge of soils for water management purposes includes such features as soil stability, infiltration capacity, and water-holding capacity, all in relation to the various forest types and conditions existing on his area.

Such information (obtainable through the help of public research agencies) will provide the forest manager with a basis for appraising the relative values of different portions of a drainage basin for water production and the prospects of increasing supplies by cover management. To make effective use of this information, however, he should understand the basic concepts involving the movement of water in and out of the soil.

First, he must know something of the differing characteristics of soils as they influence the separate processes of evaporation and transpiration. Briefly, evaporation is a physical process whose rates vary with wind velocity, temperature, relative humidity, and with the amount of water on the surface and in the soil available for evaporation. Other things being equal, the depth to which evaporation will occur in a given soil will vary with its physical characteristics. For example, it is probable that where the water table is below a depth of around 6 to 7 feet, a coarse textured sand will lose water by evaporation to a depth of at least 5 feet, whereas by contrast, evaporation from a heavy clay soil may take place to a depth of only 2 to 3 inches.

Transpiration is a biological process whose rates vary with temperature, wind, and relative humidity, and the amount of moisture available for extraction. But unlike evaporation, it is dependent upon the ability of plants to extract water from the soil. Aside from stream-bordering or swamp vegetation, the greater the depth to which the roots of plants can penetrate the soil, the greater the depth from which water available for plant use (between field capacity and wilting point) can be extracted. A pland plants whose roots extend only 2 feet down can draw on the available moisture only to that depth, whereas plants with roots 6 feet deep, have 4 additional feet of soil from which to "pump" moisture. Thus, if a given soil can store 2 inches of available water per foot of depth (assuming no additional water is provided by precipetation) the shallower rooted plants can transpire a total of only 4 inches of moisture as against the 12 inches available to the deeper rooted species. (Actually there is considerable variation in the ability of soils to store moisture. The water-holding capacity of a coarse textured sand may be as little as 0.3 inch per foot of depth, whereas a heavy clay can store as much as 3.5 inches per foot.)

Significance of Root Depth

The significance of differences in rooting depth is illustrated by the results of various studies. One experiment, located in the Wasatch Mountains in Utah, involved an aspen stand with a herbaceous understory. Here snow is the main source of water yield. The soil mantle is at least 6 feet deep and requires 2 inches of water per foot of depth, or a total of 12 inches, to bring it up to field capacity. The roots of the aspen penetrate 6 feet, those of the herb cover go to about 4 feet. Removal of the deeper rooted aspen resulted in a yearly saving of 4 inches of water (over a 3-year period) for additional streamflow. This represented the extra amount drawn up by the tree roots in the two feet of soil below the depth of the herbaceous roots. Removal of all vegetation (herbaceous cover as well as aspen) effected the largest annual saving, namely, 8 inches out of a total available water supply of 12 inches. The remaining 4 inches were lost by evaporation which probably extended here to a depth of only 2 feet. However, the extra savings obtained by removing all vegetation were accomplished at the expense of muddy surface runoff and a loss of soil amounting to 10 tons per acre, thus foreboding both undesirable water supplies and a serious erosion and flood and sediment hazard downstream from too drastic removal of the soil-stabilizing cover (2).

Suppose the roots of the aspen had been no deeper than those of the herbaceous understory. Would any water gains have been effected by its removal? Except for the possibility of decreased snow interception, the answer is in the negative because the roots of the herbaceous plants would have taken up the extra amount of moisture made available to them by removal of the moisture-competing trees.

Another illustration of the significance of rooting depth is provided by a study of soil moisture deficiencies (i.e., the difference between field capacity and the amount of water in the soil at a given time) in an area near Pullman in southeastern Washington. Soils were of the silty clay loam type and at least 17 feet deep. Soil moisture changes were measured respectively on land in summer fallow (bare), bunchgrass, alfalfa, and a tree plantation (7). Analysis of the data from this study indicates that soil moisture deficiencies by the end of the growing season varied directly with the depth to which the roots of the various plant species penetrated. Thus, the greatest deficiency, 49 inches, occurred under the alfalfa cover, whose roots extended to a depth of at least 14 feet. The next greatest deficiency, 42 inches, was under the tree cover, whose roots were 12 feet deep. The deficiency under bunchgrass, whose roots went only 6 feet down, was 19 inches. The minimum loss in soil moisture occurred on the bare area.

Heavy snow accumulations do not always mean that increased spring runoff will follow. Whether or not runoff will occur will depend

on the extent to which soil moisture deficiencies can be overcome. Sometimes all the snow melt may be needed to meet the deficiencies. For example, in the Palouse study cited above, the tree plantation caught the equivalent of nearly 31 inches of water as drifting snow. Even this large amount of moisture was inadequate to meet the soil deficiency for the entire 12-foot depth. Moisture penetration actually extended to a depth of only 9 feet, leaving an unsatisfied moisture deficit of about 12 inches. In short, no additions to streamflow could be expected from this portion of the watershed until at least an additional 13 inches of water was made available.

Studies have shown that by reducing the density of a coniferous forest cover the amount of snow water accumulation can be increased. However, as the above example reveals, unless the increase in water content is sufficient to overcome the soil moisture deficit, there will still be no runoff. Thus, if thinning should increase snow storage in an area from 6 inches to 8 inches (water content) but the soil moisture deficit at the time of snow melt was 8 inches or more, all the additional moisture (2 inches) would be retained in the soil. On the other hand, the same 2 inches per-foot deficiency in a soil only 3 feet deep would be satisfied when 6 inches of water entered the soil. Here the gain to streamflow would be 2 inches (about 107-acre feet per square mile of watershed area worth upwards of $325 delivered to a reservoir or intake).

The same basic principles apply where rainfall is the main source of precipitation, as in southeastern upland forests. In "shallow" soils, however, i.e., where evaporation extends to the full rooting depth, little or no gain should result from removing timber or other vegetation, as all or most of the increased moisture so made available would only be lost by the increased evaporation resulting from exposure of the surface to wind and sun.

This discussion brings out an important concept as to the significance of soil depth—that the extent to which timber cutting can affect the water relations of a given soil depends on the depth penetrated by the deepest-rooted species. The forest manager should therefore know the rooting habits of the various species—understory as well as overstory—as thoroughly as he knows their characteristics above ground.

The fact that certain species can grow on shallow soils by no means indicates that when growing on deep soils, their roots will still be shallow. For example, the roots of white oak, yellow-poplar, shortleaf pine, redcedar, and many other broadleaf and coniferous species can extend down 6 feet or more where soil depth and structure permit, yet these same species can also be found on soils only 2 feet deep or less over solid rock or hardpan. This emphasizes the importance of knowing the root depth of a given species for the deepest soil it occupies. The observer can thus be reasonably well assured that soils of lesser depth occupied by this species will be fully penetrated by the roots.

Marked differences in soil depth will of course be found over any sizable area. In a given watershed, for example, the higher, rougher slopes, especially on dry exposures, may have the shallowest soils. On the other extreme, the benches, coves, and valleys may have the deepest. Cultivated soils may usually be expected to be greatest in depth. This, however, is by no means always the case. Deep soils—as much as 10 feet or more—will be found on forested slopes whose cultivation has been impracticable because of other factors, such as rockiness, topography, and climate.

The previous discussion has indicated how transpiration losses are affected by root depth. This relationship is of the utmost significance for water resource management. The actual application of water resource management practices, however, also requires a knowledge of rainfall distribution as it bears on evaporation and transpiration losses.

In the case of upland areas (as distinguished from swamps or stream borders where the water table is well within reach of the roots throughout the growing season) local precipitation is commonly the only available source of moisture. As we have seen, when precipitation occurs, the amount entering the soil may or may not be sufficient to satisfy its deficiency. Assuming that it is, the excess, if any, will drain off. During the course of the growing season, transpiration will start using up the supply stored in the soil and, if no further rains occur, continue to do so until the wilting point is reached. Meantime, evaporation is also taking place.

An important difference between the two processes is that while transpiration effects water losses simultaneously throughout the entire depth of the root zone, evaporation proceeds from the surface down. Thus the occurrence of a dry soil condition at or near the surface does not necessarily indicate that the deeper soil layers are equally dry. The difference in dryness is due to the fact that throughout the upper soil layers water is being lost by both evaporation and transpiration, whereas the lower soil layers are affected only by transpiration. When, on the other hand, the soil is moister above than below, the cause may be a light rain or condensation. Although such minor amounts of precipitation may be sufficient to moisten the surface, they are entirely inadequate to satisfy the subsurface deficiency induced by transpiration.

During the growing season it is very seldom that sufficient rainfall occurs at any time to satisfy fully the soil moisture deficit resulting from evaporation and transpiration. On exceptional occasions periods of prolonged rain will occur which yield sufficient water to satisfy the soil moisture deficit and to produce runoff[1].

[1] The runoff from such prolonged rains is usually of the subsurface type and hence does not cause erosion. Such surface runoff as does occur during the growing season is usually not the result of prolonged rains but rather of hard rains whose rates exceed the capacity of the soil to absorb the water.

It does not follow, however, that runoff will occur from all parts of the watershed on which the rains fall. For example, if a given storm produced 7 inches of rain, and all soils required 2 inches per foot of depth to satisfy their moisture deficiencies, runoff would result from those soils penetrated by roots to a depth of less than 3.5 feet. No runoff, however, would occur from areas where root penetration exceeded 3.5 feet. This illustration reemphasizes the need for fully recognizing soils and root depth in evaluating the prospects of water yield from various parts of a given watershed.

Effects of Changes in Cover

A study by the U. S. Geological Survey of the effects of reforestation on three watersheds in New York State, ranging from 0.7 to 3 square miles in area, showed no change in water yield over an 18-year period following the introduction of a tree cover. Prior to planting, the area was occupied by shrubs and other vegetation whose roots extended to a hardpan layer 18 to 24 inches below the surface. The roots of the planted trees, however, also extended to the hardpan layer (*1*). These results illustrate that merely changing the watershed cover is no assurance that water yields will also be affected in one way or another.

Whether or not the removal of forest growth will increase water yield depends on the factors previously discussed plus the form in which precipitation occurs. Cutting of timber alone may or may not reduce losses due to interception, depending on whether precipitation occurs as snow or rain, the density of the understory vegetation and litter (slash, debris, leaves), and the distribution of the roots of the remaining growth.

In regions where considerable precipitation occurs during the growing season, even heavy forest thinning will not necessarily provide increased water yields. In the first place, unless no undergrowth is present, interception losses will probably not be reduced at all or at most a negligible amount. In the second place, the roots of new growth and of the remaining trees will soon take up the extra moisture. (Incidentally, this relates directly to the well-known fact that the availability of additional soil moisture following thinning is largely responsible for the increased growth rates of the residual stand.) Only by thinning to a point where root competition for moisture is competely eliminated can a substantial increase in water yield be expected.

Increased evaporation losses would also have to be considered, especially in the case of heavy thinnings and where a surface-shading understory was absent. In any event, wherever soil depth and structure are such that evaporation extends to the same depth as the roots, no gains can be expected, regardless of how heavily the timber may be cut.

Summary and Conclusions

The attainment of a greater degree of control over the flow and quality of water is a nationally recognized objective. The question, "Can we achieve such control to a material degree by manipulating the vegetal cover?" can be answered affirmatively. So far as water quantity is concerned, the reduction of forest cover may be expected to result in increased yields under the following conditions:

1. Where the major source of precipitation is *snow* and the additional supply of moisture made available by reduced interception (less increased evaporation) is sufficient to overcome the soil moisture deficiency existing at the time of snow melt (a) the greatest gains may be expected from those portions of the watershed having relatively shallow soils, (b) in areas with deeper soils, and from which spring runoff normally ensues, the prospects of increased water yield can be enhanced by removing that portion of the vegetation having the deepest rooting systems.

2. Where the major source of precipitation is rain, and root penetration exceeds the depth subject to evaporation, the greatest gains may be expected where root occupancy of the lower soil layers is materially reduced. This indicates heavy cutting (or defoliation) of deeper-rooted vegetation, including shrubs, as well as trees, provided that soil stability is not endangered.

How lasting will be the effects of reducing the vegetation will depend on the rooting systems of the incoming plants and their rate of growth.

The writers believe that the stage is set for the inclusion of water resource development in the management objectives for both private and public lands. Many technical, administrative, and financial problems remain to be worked out. But the basic principles are now believed to be sufficiently clarified to warrant consideration in formulating and applying policies, plans, and practices to commercial timberlands.

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Littleleaf Disease in South Carolina as Determined by the Forest Survey

George H. Hepting and James W. Cruikshank

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LITTLELEAF is a serious disease of shortleaf, and to a lesser extent loblolly pine (Figs. 1 and 2). Its cause is not yet known, but millions of trees over 20 years old have died of it during the past decade, and in some sections its occurrence dates back considerably further. Littleleaf seems to be associated with failure of the trees to absorb sufficient nitrogen due to a heavy mortality of feeding roots, but the cause of the death of so many roots has not yet been demonstrated.

The distribution of the littleleaf disease on shortleaf pine in the South has been determined in a general way by roadside reconnaissance over a period of 10 years. It extends from central Virginia to northeastern Mississippi, but except in the case of specific tracts, no surveys or even estimates of the numbers of trees or volumes affected, have been available. When the U. S. Forest Service resurveyed South Carolina in 1947, an opportunity was afforded to determine the amount of shortleaf pine with unmistakable symptoms of littleleaf, and to estimate the amount that recently died of littleleaf on representative field plots distributed according to standard Forest Survey procedure. This gives a sharper picture of littleleaf extent and damage than we have ever had before.

FIG. 1.—A stand of 50-year-old shortleaf pine in South Carolina, breaking up as a result of the littleleaf disease.

FIG. 2.—Branches from shortleaf pines, both with 2 years' needles on them. Left, from a littleleaf tree; right, from a healthy tree.

In South Carolina, littleleaf is confined to the Piedmont, as indicated in Figure 3. The survey crews, trained in the recognition of the disease by Elmer R. Roth of the Division of Forest Pathology, counted all affected shortleaf pines in the advanced stage of littleleaf on all ground plots in the Piedmont counties. Because of difficulties in diagnosis, no trees in the earlier stages of littleleaf were tallied and no loblolly pine was tallied, although this species is affected to a considerable degree in some sections. The figures presented, therefore, are conservative with respect to anticipated losses, since many trees in the early stages of littleleaf succumb rapidly, and an appreciable amount of loblolly is lost annually from this disease.

The average life of a shortleaf pine in advanced littleleaf has been demonstrated by T. S. Buchanan, now professor at the University of Idaho, in his Yale Doctorate thesis of 1945, to be only $21\frac{1}{2}$ years, from observations of thousands of trees

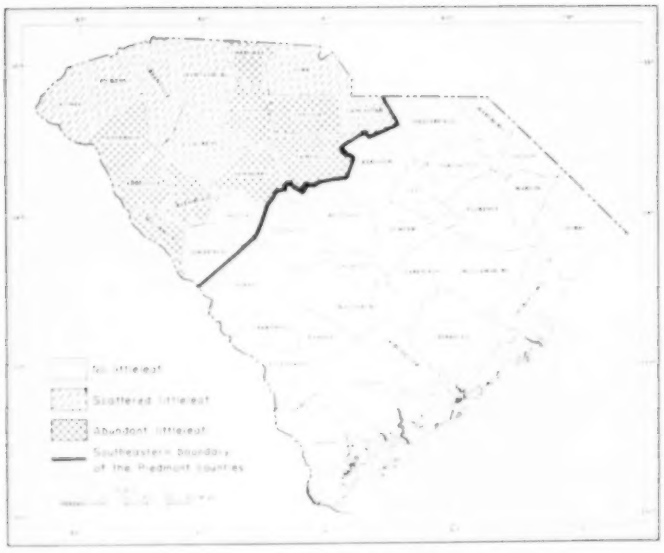

FIG. 3.—The occurrence of littleleaf in South Carolina, by counties.

on thirty-one permanent plots. Therefore, the volumes and tree tallies here reported, if divided by 2.5 provide a minimum estimate of the annual mortality from the disease to shortleaf pine in South Carolina, and provide no estimate of the losses through growth reduction.

On the basis of existing knowledge of the distribution of littleleaf, together with new information from the survey, the Piedmont counties were divided into three groups, those with no littleleaf (Edgefield and Saluda), those with scattered littleleaf (Greenville, Laurens, Lancaster, Oconee, Pickens, Spartanburg, and York), and those with abundant littleleaf (Abbeville, Anderson, Cherokee, Chester, Fairfield, Greenwood, Newberry, McCormick, and Union).

The number of trees and volumes affected by littleleaf, by county groups, are given in Table 1. Perhaps the most important feature of this table is that, for a group of nine counties where the disease is abundant, 6.4 percent of the cubic foot volume and 10.3 percent of the board-foot volume was in advanced littleleaf or had recently died of littleleaf. The higher percentage on the board-foot basis is because, as shown in Table 2, the percentage of trees affected increases with diameter.

Almost 118 million board feet of shortleaf pine was in advanced littleleaf and recently dead of littleleaf in the South Carolina Piedmont in 1947. In addition, 139 thousand cords of wood in the 6- to 8-inch diameter classes were similarly affected. With a current stumpage price of $12 a thousand for sawtimber and $2.50 a cord for pulpwood, the estimated loss, if none of this material were salvaged, would be $1,751,500.

Since this loss would be spread over approximately a 3-year period, the annual loss would be about $600,000. An effort is being made by the pulp companies, the U. S. Forest Service, and some private landowners to salvage littleleaf timber before it dies. Few southern pines can be salvaged after they die, because of the rapid attacks of stain and decay fungi and insects.

In Table 2, the relation of littleleaf to tree diameter and age, is given for the group of counties where littleleaf is abundant. The percentage of trees affected in diameters of 10 inches and larger lies between 8 and 10 percent. This means that the annual loss due to littleleaf in these counties is between 3 and 4 percent in the sawtimber sizes. The losses from littleleaf in the South Carolina Piedmont are exceeded only by the drain for lumber and pulpwood.

Table 2 also shows that the percentage of trees with littleleaf increases with age. The heavy cutting of shortleaf pine in the higher age classes, together with the very considerable losses from littleleaf already sustained in these ages in these nine counties, has greatly limited the basis for the data in the higher ages. The percentage diseased above 54 years, as shown in Table 2, is probably not trustworthy in view of these circumstances.

Littleleaf losses in Alabama unquestionably exceed those in South Carolina. The Georgia situation is probably not very different from South Carolina, while losses in North Carolina, Virginia, Tennessee, and Mississippi are each

TABLE 1.—NUMBER OF TREES AND VOLUME AFFECTED BY LITTLELEAF, BY COUNTY GROUPS
(All volumes and numbers of trees are in thousands)

County group	Total shortleaf			Shortleaf pines with littleleaf							
	Trees	Volume		Trees		Cubic feet		Board feet			
	Number	Cubic feet	Board feet	Number	Percent	Number	Percent	Number	Percent	Percent, cubic, avg. dead	Percent, initial, avg. dead
No littleleaf (2 counties)	10,541	51,372	156,159	0	0	0	0	0	0	0	0
Littleleaf scattered (7 counties)	88,963	482,724	1,210,358	870	1.0	8,217	1.7	27,475	2.3	2.5	
Littleleaf abundant (9 counties)	69,102	359,387	842,606	2,910	4.2	23,044	6.4	66,128	7.8	10.3	
Total	168,606	893,483	2,189,118	3,781	2.2	31,261	3.5	93,603	4.3	5.4	

probably considerably below South Carolina losses. In the case of the recent resurvey of South Carolina, the Forest Survey has proved to be a useful means toward providing better information on the damage being caused by a tree disease. Similar information is now being gathered on the losses from dry face in the turpentine belt of Florida. Only through such systematic surveys can valid estimates of such losses be obtained, and only through sound estimates can the importance of these problems be evaluated, and the amount of effort that should be directed toward them be determined.

Since the Forest Survey has recently been depending more heavily on aerial photographs and less on ground plot samples, there are certain limitations to the amount of detailed information the Survey can provide concerning forest pests. However, the Survey still takes several thousand ground plots in each state. Thus there might be advantages in attaching trained forest pest specialists to Survey inventory crews on their periodic resurveys so that incipient outbreaks could be detected early and losses evaluated. In addition, better information could be obtained on cull, defects, and mortality from insects and diseases normally present in the forests.

TABLE 2.—RELATION OF TREE DIAMETER AND AGE TO LITTLELEAF IN THE NINE COUNTIES WHERE LITTLELEAF IS ABUNDANT

(All numbers of trees are in thousands)

D.b.h. class	Excluding trees dead of littleleaf			Including trees dead of littleleaf		
	Total trees	Littleleaf trees		Total trees	Littleleaf trees	
Inches	*Number*	*Number*	*Percent*	*Number*	*Number*	*Percent*
5.0 to 8.9	52,809	1,676	3.1	54,180	1,987	3.7
9.0 to 12.9	12,822	1,034	8.1	12,987	1,199	9.2
13.0 and over	2,431	209	8.5	2,451	240	9.8
Age class						
Years						
15 to 34	177,801	1,008	.6	177,981	1,188	.7
35 to 54	68,065	1,467	2.2	68,234	1,636	2.4
55 and over	13,967	435	3.1	14,134	602	4.3

Pruning Western White and Ponderosa Pine Appears Profitable

Artificial pruning of trees to produce knot-free lumber is a forest culture measure that appeals to lumberman and forester alike. It is the wide spread in value between Selects and Common lumber that suggests that pruning may be profitable. In a diagrammatic comparison between pruned *butt logs* and unpruned *butt logs*, results contained in Northern Rocky Mountain Forest and Range Experiment Station Research Note #85 show a marked increase in lumber values that were far above the costs of pruning. The increase in lumber values by pruning depends upon the price differential between Select and Common lumber, the size of the tree at pruning, and its size at harvesting. September 1949 lumber prices were used in the study. When the trees were pruned to produce a cylindrical, knotty core of six inches diameter with an additional radial inch allowed for pruning-wound healing, a pruned, 16-foot, 16-inch d.i.b. small end *butt log* of white pine returned 31 percent more lumber value (after deducting pruning costs) than a comparable unpruned log. The same comparison for ponderosa pine showed a 60 percent increase. In terms of board foot volume, lumber tally, for the same logs and pruned core a $30.09 per thousand gain for white pine and a $34.91 per thousand gain for ponderosa remained after the pruning costs were deducted. These gains when expressed as compound interest on the pruning investment amounted to 3.4 percent for white pine and 3.0 percent for ponderosa. Even more striking increases occur when the trees are pruned earlier. On the other hand, the pruning of larger trees, say 10 to 12 inches d.b.h., evidently is not good business. Such trees take too long to produce clear boards in significant quantities.

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Determination of Air Permeability of Soil by Means of a Sphygmomanometer

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DURING RECENT YEARS a number of methods have been introduced for testing air permeability of soil (2, 4, 5). These methods are based on pressure differentials resulting from resistance of the soil to the passage of forced air. Analyses of this nature promise to be of considerable value in application to problems of soil management. However, the testing equipment suggested thus far was found to be rather cumbersome for use in forestry practice. Therefore, a simplified air permeameter was devised for analysis of forest soils. This equipment and its possible application in silviculture are described in this paper.

Description of Apparatus

The air permeameter consists of a brass cylinder connected by rubber tubing to a sphygmomanometer, i.e. appartus for the determination of blood pressure (Fig. 1). The cylinder, 6 inches long and 1.25 inch in diameter, is graduated at 1-inch intervals; it is sharpened at the open end and is provided at the top with a 1-inch air inlet, corrugated for attachment of ¼-inch rubber tubing. The rubber tubing, connecting the manometer and the constant pressure chamber, is split to allow insertion of the rubber lateral from the brass cylinder by means of a "T" tube. The chamber is provided with either a rubber hand bulb or a foot pump.

Use of the Air Permeameter

The brass cylinder is inserted in the soil to the desired depth and the constant pressure chamber filled with air by means of the hand bulb or foot pump until the mercury reaches a maximum height and comes to equilibrium. The reading is recorded directly in millimeters of the mercury column (Fig. 2). In studies of compacted soils of grazed woodlots, the 2-inch depth of insertion was found to be most satisfactory.

Determinations should be made at least 24 hours after rain to insure that the soil moisture was at field capacity or less. Since the air permeability of soil is not influenced by capillary pores, the differences in soil moisture below field capacity do not modify appreciably the results of analyses (1). As pointed out by Janert (1), the air permeability of soil is not necessarily identical with soil porosity. This is because a structured soil with a high non-capillary pore space may be sealed on the surface due to erosion, action of rain drops, or fertilizing materials.[2]

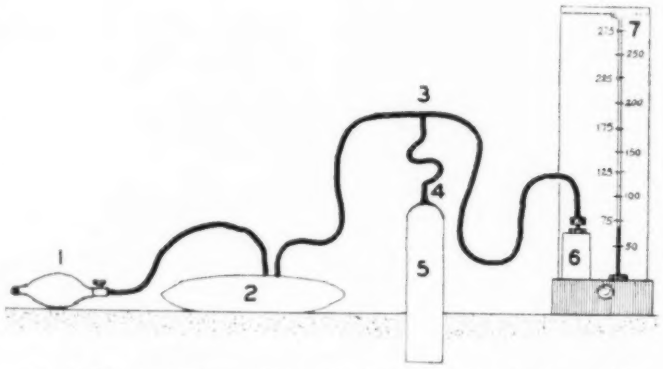

FIG. 1.—Portable sphygmomanometric unit for the determination of air permeability of soil (schematic presentation): (1) rubber compression bulb provided with an air release valve; (2) constant pressure chamber (cloth reenforced rubber bag); (3) "T" connection for the ¼ inch rubber tubing; (4) corrugated inlet for attachment of rubber tubing; (5) brass cylinder, 6 inches long and 1.25 inch in diameter; (6) mercury reservoir; (7) mercury column of the sphygmomanometer graduated at 2 mm. intervals for measuring total pressure up to 280 mm.

The sphygmomanometer of indicated type can be replaced by an aneroid pressure gauge, and a small air pump can be used instead of the compression bulb.

FIG. 2.—Taking the "blood pressure" of soil. A general view of the air permeameter in operation.

Results of Analyses

Preliminary investigations of air permeability were conducted in three farm woodlots; a portion of each had been grazed for a period of ten or more years, while the other portion was ungrazed. The soil studied included light

[1] The study was carried on with the support of the Wisconsin Conservation Department. Publication is authorized by the director of the Wisconsin Agricultural Experiment Station. The writers acknowledge the help in various phases of the study of O. K. Voigt, R. S. Pierce, and P. A. Roberts, assistants in soils.

[2] In the words of *Life*'s correspondent (June 12, 1950): "On level land the particles do not migrate but form mud, some of which seeps into the crevices and cracks of the earth and seals them up. Level ground can thus be virtually waterproofed in a few minutes, depriving underground reservoirs of much needed rain . . . The mud left behind, deprived of many loosely held nutrients, congeals into a crust that inhibits plant growth." Technical aspects of this important problem are described by Ellison (3).

TABLE 1.—AIR PERMEABILITY OF SOIL IN UNGRAZED AND GRAZED WISCONSIN FARM WOODLOTS AS DETERMINED BY MEANS OF A STHYGMOMANOMETRIC UNIT

Location of study areas	Type of soil and forest cover	Number of determinations	Minimum reading	Maximum reading	Weighted average
			mm.	*mm.*	*mm.*
Greenwood Goose Refuge, Wisconsin Conservation Department, near Hancock	Coloma sandy loam, melanized phase; second growth mixed oaks, about 70 years old	6	9	16	12.3
	Ditto, adjacent oak stand depleted by grazing	9	28	36	32.2
West Hill Farm, University of Wisconsin, near Madison	Miami silt loam, crumb mull; red and white oak, American elm, and black cherry, about 70 years old	12	6	11	8.2
	Ditto, adjacent pasture with sparse growth of oak trees	14	34	86	70.5
Spring Grove Woods, near Monroe	Downs silt loam, prairie-forest mull, 18 inches deep; virgin stand of hard maple, 200 years old	7	7	12	9.3
	Ditto, adjacent hard maple stand of similar age, depleted by grazing	7	47	71	55.4

sandy loams (Coloma series), silt loams of calcareous drift (Miami series), and silt loams derived from loess (Downs series). The results are presented in Table 1.

Examination of results leaves no doubt as to the ability of the instrument to detect the compaction and reduced air permeability of soil due to trampling of livestock. Considering the general heterogeneity of forest soils, unexpectedly small differences were observed between duplicate readings. This was particularly true of undisturbed forest soils; grazed soils often show considerable variation because livestock have a tendency to follow certain paths and avoid certain areas, such as brush thickets.

Advantages of the Proposed Method and Its Possible Applications in Silvicultural Practice

The most important feature of the suggested method is the rapidity with which it can detect the degree of impermeability of soils, resulting from compaction or "sealing" of the soil surface. The simplicity of the analysis, requiring no reagents, and the portable size of the equipment are other advantages that may be pointed out.

The compaction of soil due to grazing or other adverse influences should be of greatest concern to silviculturists. Such a condition lowers the infiltration capacity of the soil and thereby deprives forest stands of moisture which is lost either through evaporation or run-off. In some instances increased run-off leads to acute erosion of soil. Furthermore, compaction of soil exerts an adverse effect on the growth of forest stands, especially that of young reproduction, because of inadequate aeration.

Incidental observations suggested that the air permeameter may prove to be of value in detecting sealing of the surface soil in nursery seedbeds. Such sealing may result from surface accumulation of soluble fertilizer salts, carbonates from hard irrigation water, use of finely dispersed or macerated organic matter, application of sulfuric acid, other fungicides or insecticides, and a number of other reasons.

In silvicultural research, random determinations of air permeability of soil may serve as a quick check on the uniformity of soil conditions on proposed sample plots.

It is entirely possible that the method will provide useful information on soil conditions in selectively logged stands and sites proposed for reforestation. However, none of these aspects has yet been investigated. Judging from results of recent studies, for instance those of Storie and Weir (*6*), the impermeability of both surface soil and deeper soil horizons is steadily gaining in recognition as a factor of plant growth.

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Growth-Strength Relations of Red Pine[1]

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RED PINE, *Pinus resinosa* Sol. was formerly one of the more important timber trees, particularly in the Lake States region. Now, although the old growth is nearly gone, thousands of acres of plantations of this species have been established in the northeastern United States because of its desirable qualities as a tree and the wide variety of uses for which the wood is suitable (*17*, 29). It seemed desirable, therefore, to evaluate the relationships between the various influencing factors and the mechanical properties of the wood to provide information which could serve for the guidance of the owners and managers of young stands and for the users of the wood produced.

The material collected in the field was entirely from planted stands which ranged in age from 25 to 44 years. Nine temporary sample plots were established, selected from a list of Connecticut red pine plantations which had been previously classified as to site quality (*8*). It was planned to use 10 trees from each plot, but 11 or 12 were actually cut to allow the culling of material later if necessary. Bolts 4.5 ft. in length were cut with their centers at breast height. Flitches 2.5 in. thick were sawn from the bolts along the north-south diameters, and air-dried to approximately 12 percent moisture content. Each flitch was then accurately resawn to yield a series of 0.75-inch square sticks along each radius. While it probably would have been desirable to have made the tests with standard-sized specimens, A.S.T.M. (*1*), the relatively small diameters of the trees made a reduction in the size of the cross-section necessary in order to obtain a series from each radius.

Three mechanical tests were run — static bending, compression parallel to the grain, and toughness. In the static bending test for small clear specimens, a beam is supported near each end and the load is gradually applied at the center. In the test for compression parallel to the grain, the specimen is set on end and the load is gradually applied to one end. In the test for toughness, the specimen is placed behind supports near the ends and the load is applied as an impact at the center.

One specimen for static bending, one for compression parallel to the grain, and two for toughness were cut from each stick. The first two tests were made on a universal testing machine while the toughness test was made on the Forest Products Laboratory toughness machine. The lengths of the static bending and compression parallel specimens were reduced due to the reduction in cross-section. In the case of compression parallel, only maximum crushing strength was obtained since it was not possible to attach a compressometer over the short span resulting from the reduction in length. It was necessary to make some special items of accessory equipment and to reduce the speeds for both tests because of the reduction in size. After culling out slightly defective specimens, 392 static bending, 383 compression parallel, and 714 toughness tests were made.

The moisture content at the time of testing was determined for each static bending and compression parallel specimen by oven-drying and weighing sample sections. After oven-dry weight was obtained, the samples were coated with paraffin and specific gravity was determined by the immersion method. An average figure for moisture content of the toughness specimens was obtained from a sample consisting of one-half of every tenth specimen instead of individual determinations.

The number of annual rings per inch and percentage of summerwood were obtained for each specimen and measurements were taken cumulatively of the springwood and summerwood across the surface of the cross sections. Each measurement was taken to the nearest 0.01-inch and a total of 6,500 measurements were made.

Load-deflection data were recorded during the static bending tests and were plotted for each specimen tested to form the usual "stress-strain" diagrams. The mechanical properties of modulus of rupture (cross-breaking strength), fiber stress at proportional limit, modulus of elasticity (stiffness) and maximum crushing strength were computed using the standard equations. The preceding mechanical properties values were then adjusted to 12 percent moisture content by the use of the equation method of Markwardt and Wilson (*22*) in which Markwardt and Wilson's values for green and dry (12 percent moisture content) red pine were used to establish the fraction which became a constant in the equation.

Toughness values (work) in inch-pounds were obtained from a prepared table, Forest Products Laboratory (*11*), but no adjustments were made in the data for moisture content. However, the average moisture content of the specimens was found to be 14.27 percent.

The average values for all physical properties compared with those presented by Markwardt and Wilson (*22*) for old growth red pine are shown in Table 1.

It has been found by Garland (*14*) and by Schrader (*32*) that anatomical factors are related to mechanical properties, and it has been shown, Ritter (*30*), Bailey

[1] This article is based upon a doctorate dissertation, "Growth Strength Relations of Red Pine; an Investigation of the Effects of Various Influencing Factors Upon the Mechanical Properties of the Wood of *Pinus resinosa* Sol.", Yale University, 1943. The author wishes to express sincere appreciation to Mr. H. W. Hicock, Dr. C. I. Bliss, and Mr. A. R. Olson of the Connecticut Agricultural Experiment Station for making the study possible and for generous assistance in various phases of the field and laboratory work, and to Dean G. A. Garratt and Professors H. J. Lutz and W. H. Meyer of the School of Forestry, Yale University, for advice during the progress of the work and for review of the original manuscript.

TABLE 1.—AVERAGE VALUES OF PHYSICAL DATA FOR RED PINE

	Present study	Markwardt and Wilson (12)
Origin of material	Connecticut plantations	Wisconsin old growth
No. of trees tested	88	7
Age	31.4 [1]	Unknown
Rings per inch	6.61 [1]	22
Summerwood (percent)	17.52 [2]	41
Specific gravity	0.360 [3]	0.51
Modulus of rupture (lbs. per sq. in.)	7,975 [4]	12,500
Fiber stress at proportional limit (lbs. per sq. in.)	4,477. [5]	9,400
Modulus of elasticity (1000 lbs. per. sq. in.)	1,069.9 [6]	1,800.0
Maximum crushing strength (lbs. per sq. in.)	3,680. [7]	7,340.
Toughness (inch pounds)	79.5 [8]	—

Basis for each average:
[1] Nine even-aged sample plots
[2] 3,250 determinations
[3] 775 determinations
[4] 392 tests
[5] 383 tests
[6] 714 tests

and Kerr (4, 5) and Bailey and Vestal (6), that the secondary, or main structural portion of the cell walls of tracheids is composed of a cellulosic matrix oriented at an angle to the longitudinal axis of the cells. The elongated complexes of the secondary walls are usually called fibrils.

In order to investigate additional factors which might influence mechanical properties, an anatomical study was undertaken in addition to the main project. Since previous work, Harlow (15), Bailey and Shepard (3) and Mac Millen (21) indicates that fiber (tracheid) length has little relation to mechanical properties, measurements of tracheids were confined to the transverse (radial) direction. It was decided to measure percentage of wood substance on the radial surface and alinement of fibrils with the longitudinal axes of the tracheids.

Values for modulus of rupture and for modulus of elasticity were plotted over specific gravity in two scatter diagrams, Figures 1 and 2, and rectilinear relationships were apparent in both diagrams. On each diagram, ten well-distributed points were selected along the center, or "normal" lines and ten were selected along each of the outer limits parallel to the "normal" lines but showing the greatest positive and negative deviations from them. Nine duplications were found between the two diagrams which resulted in a total of 51 specimens represented.

Samples in the form of 0.75-inch cubes were cut from the 51 beams as close as possible to the points of failure and sections were cut 10 microns in thickness along the radial surface in order to show the rays. Four sections were made from each block and the two best were stained and mounted on slides in permanent form.

Because of observed departures from the general trend of decrease in cell width across each annual increment, the second five cells of the springwood and the last five cells of the summerwood, disregarding the last cell, were selected for measurement. Measurements of radial width of cell and of lumen were made on ten tracheids per increment, on not less than two nor more than four per section at 950 × with an ocular micrometer and oil immersion objective. A total of 2,540 measurements were made and average radial tracheid width, single cell wall thickness, and percentage of wood substance on the radial surface were obtained for each specimen. Averages for all sections were as follows: radial tracheid width, 32.9 microns; wall thickness, 3.50 microns; wood substance, 20.7 percent.

No attempt was made to get averages of angle of alinement of fibrils. Since adequate samples from any point in the annual increments may be considered as representing the section two well-separated increments were selected and within each one, the next-to-last five cells were used for measurement. Since the bordered pit apertures are parallel to the fibrils of the secondary cell walls, the alinements of these apertures were measured in preference to the more difficult task of measuring the alinements of the substance of the cell wall itself. The pit apertures of half-bordered pit pairs between tracheids of the summerwood and ray parenchyma cells were used for measurement because their large size and long apertures aid accuracy of measurement of the angle of orientation. The ends of each fusiform pit aperture were plotted on cross-section paper by means of a camera lucida, a line drawn through them, and the angle read from a protractor. This work was done at 440 × and a total of 510 alinements were measured, ten on each section. The angle of alinement of the fibrils with the axis of the tracheids was found to vary

FIG. 1. Scatter diagram of all values of modulus of rupture plotted over specific gravity. Mean line not mathematically fitted. Locations of samples used for anatomical study plotted with X's.

FIG. 2. Scatter diagram of all values of modulus of elasticity plotted over specific gravity. Mean line not mathematically fitted. Locations of samples used for anatomical study plotted with X's.

from 8.3 to 55.8 degrees in the region of the annual increments sampled.

Analyses of the Data

The properties of wood are widely variable due to the large number of factors which influence them, either directly or indirectly. Not all factors were measured in this study; in fact, there may be still undiscovered factors which strongly influence porperties. However, those factors which are generally thought to have some influence on properties were measured and these fall into two classes

the factors which are a part of the specimen (internal) and those which are outside the specimen (external). Those of the first type included, were, rate of growth, amount of summerwood, specific gravity, amount of wood substance, and alinement of fibrils, while those of the second or external type were site quality, individual trees, orientation (north or south) within the tree, and position of the specimen within the radius.

The first analysis dealt with the relations of the factors (except anatomical factors) to modulus of rupture, fiber stress at proportional limit, and modulus of elasticity, the mechanical properties measured by static bending. Trees which did not yield at least two specimens from each radius were omitted in the analysis of covariance and regression, which resulted in the use of 280 specimens from 70 trees.

After computation of the values for the general analysis of covariance table (not shown), the partial regression coefficients, their standard errors and t values were computed from the error row with 183 degrees of freedom, for the influence of the internal factors as follows:

	x_1	t	x_2	t	x_3	t
R	1.7697 ± 0.7995	2.2	0.1603 ± 0.2118	—	0.0387 ± 0.0510	—
r	0.3777 ± 0.6418	—	0.0043 ± 0.1714	—	0.1508 ± 0.0412	3.6
E	5.7872 ± 1.2810	4.4	0.0328 ± 0.3410	—	0.0080 ± 0.0821	—

R = Modulus of rupture.
r = Fiber stress at proportional limit.
E = Modulus of elasticity.
x_1 = Rings per inch.
x_2 = Percentage of summerwood.
x_3 = Specific gravity.
t = Ratio of the regression coefficient to its standard error.

The regression coefficient is the amount of change in the property for each unit increase in the influencing factor. The set of regression coefficients above is in effect when the external factors of sites, trees, orientation, and position are held constant. The coefficients for the influence of percentage of summerwood were all less than their errors, indicating lack of significance of this factor, and the same condition was found between specific gravity and both modulus of rupture and modulus of elasticity, as well as between rings per inch and fiber stress at proportional limit. Rings per inch appeared to be the strongest factor.

The partial regression coefficients were then computed from the total row of the general table with 279 degrees of freedom, as follows:

	x_1	t	x_2	t	x_3	t
R	2.7437 ± 0.3802	7.2	-0.0695 ± 0.1944	—	0.1211 ± 0.0366	3.4
r	1.3539 ± 0.3052	4.5	-0.0661 ± 0.1559	—	0.0518 ± 0.0292	—
E	6.7837 ± 0.6144	10.0	0.0078 ± 0.3141	—	0.1869 ± 0.0592	3.2

The set of regression coefficients above is in effect when the external influencing factors are not controlled but allowed to vary at will. Specific gravity was found to have a strong influence upon both modulus of rupture and modulus of elasticity but very little effect upon fiber stress at proportional limit. Rings per inch had a highly significant effect upon all three properties. Percentage of summerwood, as in the first set of coefficients, had no significant influence upon any of the properties.

The general table showed that the influence of side of tree (north or south) had no significant effect upon mechanical properties, but as might be expected, the effect of position as between A, or farthest outside specimen and B, or farthest inside specimen in each radius, was very strong. This last effect is not due to position in itself, but due to the effects of other factors.

A new analysis of covariance table was computed with the values adjusted for the elimination of percentage of summerwood. Considerable variation between A and B positions remained not accounted for by rings per inch and specific gravity, which was probably due to the effects of other factors such as anatomical ones not included in the analysis. Site index was found to have a strong effect upon mechanical properties, but its effect was negative since strength and stiffness decrease as site index increases. As in the first general table using all three factors, the effect of side of tree was not significant.

New partial regression coefficients and their standard errors were as follows:

	x_1	t	x_3	t
R	1.903 ± 0.775	2.5	0.043 ± 0.051	—
r	0.381 ± 0.626	—	0.151 ± 0.041	3.7
E	5.560 ± 1.229	4.5	0.007 ± 0.080	—

The effect of rings per inch was significant upon modulus of rupture and highly significant upon modulus of elasticity, but not significant upon fiber stress at proportional limit. The effect of specific gravity was highly significant upon fiber stress at proportional limit but not significant upon either modulus of rupture or modulus of elasticity.

Sets of partial regression equations were computed for the two factors and the three properties from the variation within sites, between trees and within trees, and it was found that the effect of specific gravity was significant only for fiber stress at proportional limit within trees. These two sets of partial regression coefficients were then combined to form a general set for the variation within and between trees as follows:

	x_1	t	x_3	t
R	1.602 ± 0.515	3.1	0.0385 ± 0.064	—
r	$0.592 \pm 0.4[illegible]$	—	0.0178 ± 0.052[illegible]	—
E	4.481 ± 0.865	5.2	0.0831 ± 0.0996	—

Regarding the variation in mechanical properties within and between trees when the effect of site quality was held constant, rings per inch had little effect upon fiber stress at proportional limit but a highly significant effect upon both modulus of rupture and modulus of elasticity. Specific gravity had no significant effect upon any of the three properties and thus can be disregarded when dealing with material from one site only.

A set of partial regression equations were computed for the relations between the two factors and the properties from the remaining or "unexplained" variation among specimens within trees as shown below:

	x_1	t	x_2	t
R	2.5180 ± 0.0958	2.8	-0.0618 ± 0.0557	—
r	1.3077 ± 0.7705	—	0.1269 ± 0.0474	2.7
E	8.8099 ± 1.4961	5.9	0.2182 ± 0.0921	2.4

The influence of rings per inch was highly significant upon both modulus of rupture and modulus of elasticity. The influence of specific gravity was significant upon modulus of elasticity and highly significant upon fiber stress at proportional limit. This remaining variation is undoubtedly due to the effects of factors not included in the analysis, both unknown ones and known ones such as anatomical factors and resin and compression wood.

A second analysis was made of the relations of the same three factors with the strength data from the tests of compression parallel to the grain and toughness. As in the first analysis, trees which did not yield at least two specimens on each radius were omitted, which left a total of 272 specimens from 68 trees. In this analysis, only the relations due to variation among the individual specimens were studied.

Gross correlation coefficients and coefficients of determination were computed for the relations between the factors and properties as presented in Table 2.

The gross correlation coefficient is a measure of the strength of the relationship between variables when the effects of other affecting variables are not controlled, or held constant, but allowed to vary at will. Its value cannot exceed 1.0. The coefficient of determination (which is the square of the correlation coefficient), may be a better measure of correlation for it is the percent of the total variation accounted for by the relationship measured. The highest correlation coefficient was between rings per inch and maximum crushing strength but those between rings per inch and toughness, between specific gravity and maximum crushing strength, and between the two influencing factors, rings per inch and specific gravity were fairly high. Percentage of summerwood showed only a very low correlation with the strength properties.

The partial regression coefficient, their standard errors and t values were as follows:

	C	t	T	t
x_1	1.710 ± 0.170	9.9	4.67 ± 0.72	6.5
x_2	-0.140 ± 0.090	—	1.39 ± 0.38	3.6
x_3	0.091 ± 0.017	5.4	0.23 ± 0.07	3.3

C = Maximum crushing strength.
T = Toughness.
x_1 = Rings per inch.
x_2 = Percentage of summerwood.
x_3 = Specific gravity.

With 268 degrees of freedom involved, all regression coefficients with the exception of that between maximum crushing strength and percentage of summerwood, were found to be highly significant. Those between rings per inch and both properties were particularly high as was that between specific gravity and maximum crushing strength. Thus, when the relations of these mechanical properties of individual specimens with the factors are tested with the variation due to other factors controlled, all three factors have a highly significant effect upon toughness, but only rings per inch and specific gravity have a highly significant effect upon maximum crushing strength.

The third analysis dealt with the relations between the anatomical factors and the mechanical properties as determined by the static bending tests. Rings per inch was included because of its consistently strong relationships in previous analyses. Fiber stress at proportional limit was omitted because of its previous weak relationships. The correlation coefficients and coefficients of determination were as presented in Table 3.

The highest correlation coefficients were those between fibril angle and the two mechanical properties, and effect of fibril angle accounted for more than 61 percent of the variation in both cases. The relationships with fibril angle are negative, for mechanical properties decrease in value as fibril angle increases. The correlation coefficients between rings per inch and the two properties and between rings per inch and the other two factors were high. It is interesting to note the particularly high degree of correlation between rings per inch and fibril angle, the two strongest influencing factors.

TABLE 2.—CORRELATION COEFFICIENTS AND COEFFICIENTS OF DETERMINATION FOR THE RELATIONS BETWEEN THE FACTORS AND BETWEEN FACTORS AND PROPERTIES

Properties and Factors	Correlation Coefficients	Coefficients of Determination
C,1	0.699	0.489
C,2	0.307	0.094
C,3	0.604	0.365
T,1	0.619	0.383
T,2	0.463	0.214
T,3	0.518	0.268
1,2	0.487	0.237
1,3	0.620	0.384
2,3	0.381	0.144

C = Maximum crushing strength.
T = Toughness.
1 = Rings per inch.
2 = Percentage of summerwood.
3 = Specific gravity.

The partial regression coefficients, their standard errors and t values were as follows:

	R	t	E	t
x_1	1.5499 ± 0.8705	—	3.5259 ± 1.6616	2.1
x_2	1.2499 ± 0.2292	5.4	1.8228 ± 0.4373	4.2
x_3	2.3479 ± 1.5200	—	2.9436 ± 2.5188	—

x_1 = Rings per inch.
x_2 = Fibril angle.
x_3 = Percentage of wood substance.

The partial regression coefficients for the effect of fibril angle upon modulus of rupture and upon modulus of elasticity were both highly significant and are indicative of a strong effect of fibril angle upon both properties when its effect is tested alone, with other factors controlled. The effect or rings per inch upon modulus of elasticity was significant but upon

TABLE 3.—CORRELATION COEFFICIENTS AND COEFFICIENTS OF DETERMINATION FOR THE RELATIONS BETWEEN THE FACTORS AND BETWEEN FACTORS AND PROPERTIES

Properties or Factors	Correlation Coefficients	Coefficients of Determination
R,1	0.637	0.406
R,2	0.782	0.612
R,3	0.302	0.091
E,1	0.738	0.545
E,2	0.783	0.613
E,3	0.564	0.318
1,2	0.731	0.534
1,3	0.697	0.394
2,3	0.507	0.257

R = Modulus of rupture.
E = Modulus of elasticity.
1 = Rings per inch.
2 = Fibril angle.
3 = Percentage of wood substance.

modulus of rupture, a weaker relationship was apparent. The effect of percentage of wood substance on the radial surface, was not significant upon either property. It is difficult to account for the negative nature of the coefficient between modulus of rupture and percentage of wood substance but since the relationship was weak, this may be due to chance.

The magnitude of the correlation coefficients between fibril angle and the two properties were very high for relations involving biological material. Because of the evident strong effect of fibril angle upon the mechanical properties shown by the correlation coefficients when the other factors were uncontrolled and by the partial regression coefficients with other factors held constant, the advisability of more work with this factor was indicated.

Discussion

The presence of compression wood, [19, 25, 28], was noted in four of the stands but no attempt was made to eliminate specimens containing it since it was not severe and, like high resin content, it was considered to be a valid part of the error of the analysis. Both of these abnormalities tend to disturb normal growth-strength relations, particularly those between specific gravity and mechanical properties, but since they are both of fairly common occurrence in coniferous stands, it seemed logical to include them if the results were to have practical value. However, stronger relationships undoubtedly would have been obtained in the analysis, had their effects been held constant since they both increase specific gravity without increasing strength values.

The types of failures of the specimens during the tests were roughly associated with mechanical properties. In static bending, simple tension failure when accompanied by compression failure was usually associated with high cross-breaking strength. The failure types became more brashy as strength and stiffness decreased. (See Figures 3, 4 and 5). Two failure types in addition to the standard ones were observed during the tests of compression parallel to the grain. The first was bending of the column without other visible failure, and the second was buckling at one side of the specimen, usually near the center. Both types occurred in specimens of low strength and stiffness.

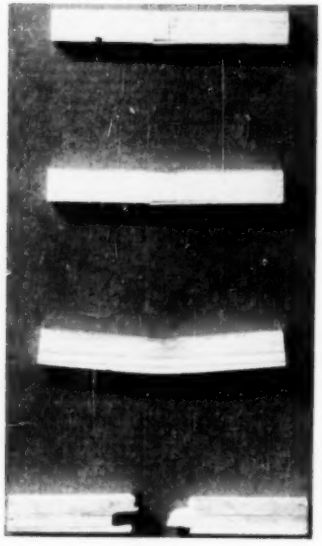

FIG. 3.—Types of failure encountered in static bending tests. From top to bottom: simple tension; simple tension with compression; excessive compression in beam with compression wood; and brash tension.

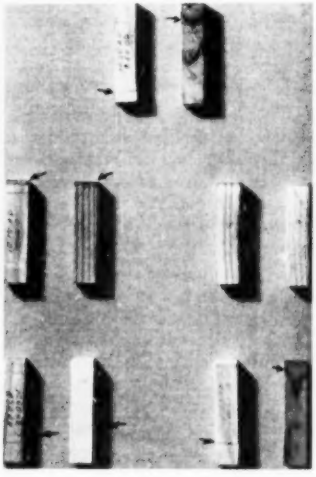

FIG. 4.—Types of failure encountered in compression parallel to the grain. *At top*, shear; *left center*, crushing at ends; *left bottom*, buckling; *right center*, bending; *right bottom*, wedge split.

In Table 1, the old-growth red pine has higher values for the mechanical properties than the younger trees of this study. However, it should not be inferred from this that plantation trees or second-growth trees produce wood which is inferior to that produced by old-growth. It should be noted that the other physical properties are higher also in the old-growth trees, moreover, the old-growth data were obtained from only five trees. If the rate of growth and other influencing factors were the same in the second growth or plantation trees as in the old-growth trees, there is no reason why the mechanical properties should not be the same. This is indicated in figures 6, 7 and 8. Lack of material of high ring count makes for roughness at the upper ends of the graphs but the trends are obvious. For instance, if the average number of rings per inch of the young trees had been 22, the same as the old-growth, then the modulus of rupture would have been approximately 12,500 lbs., the same as that of the old-growth.

Since unfortunate comparisons have been made in recent literature

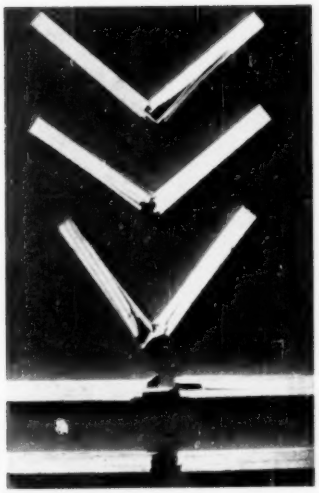

FIG. 5. Types of failure encountered in toughness tests. From top to bottom in order of toughness: splintering tension with some compression on the upper side, tension, brashy tension, brash and extremely brash.

which have implied that as a general thing, old-growth trees produce stronger wood than second growth and plantation trees. This is a fallacy and is no more logical than saying that native men are stronger than immigrant boys. The mechanical properties of wood are determined by growth conditions and possibly by certain hereditary characteristics which effect the directly influencing factors, which in turn affect mechanical properties. The author has seen no evidence to support an assumption that a tree established by natural seeding 200 years ago, inherently produces stronger wood throughout its life than one established by natural seeding 30 years ago, or by planting 20 years ago. If strength values are to be considered in the wood being produced by the new stands, the proper procedure would be to secure as close original spacing as practicable and then to control the rate of growth after the crowns have closed.

The general relationships between the growth of conifers and the mechanical properties of the wood have been recognized but most of the investigations have been on a rather broad basis since the difference in the properties of the wood from different sites or from stands with different rates of growth has been studied—Harlow (15), Jalava (16), Kalnins and Liepins (18), Lubisch (20), Paul (25 and 26), Peck (27), and Rog (31). The present study has used the individual wood specimen as its basis, but in addition, has considered variation resulting from sites (plots), trees, and positions within trees.

It was evident from the analysis of static bending that the external influencing factors of site, trees, and position within the radius strongly affected the five mechanical properties. Site, however, had a negative effect, since the higher the site index, the lower the stiffness and cross-breaking strength. The effect of orientation within the trunk (north or south) was not significant.

Of the internal factors, the three analyses showed the strongest one to be fibril angle; the second, rings per inch; and the third, specific gravity. Percentage of summerwood, contrary to popular belief, did not show an effect upon any one of the mechanical properties sufficiently strong to warrant its further testing beyond the first stages of the first analysis. Percentage of wood substance also, did not show a significant relationship with either cross-breaking strength or stiffness, and this, like the failure of percentage of summerwood to show relationships of any importance, is contrary to popular belief, but nevertheless is evidently true for red pine.

The influence of specific gravity upon modulus of rupture and modulus of elasticity was strong but its influence upon fiber stress at proportional limit was negligible when the effects of external factors were not controlled. However, within and between trees, within sites, specific gravity did not show a significant effect upon any of the mechanical properties. This means that for lumber or other products cut from trees growing on one site, specific gravity cannot be used to indicate cross-breaking strength, fiber stress at proportional limit, or stiffness. However, in products derived from trees growing on several sites, specific gravity has some effect upon properties and should be considered.

Alinement of fibrils within the secondary cell walls proved to have outstandingly strong relationships with the mechanical properties and it may be that this is the main factor influencing them, for its strong effect was apparent even in the limited number of specimens used in the third analysis. This effect probably accounts for a good part of the remaining variation in the analysis of the static bending data.

Mechanical properties of wood depend directly upon the qualita-

FIG. 6. Average values for modulus of rupture plotted over rings per inch by one inch classes.

FIG. 7. Average values for maximum crushing strength plotted over rings per inch by one inch classes.

FIG. 8. Average values for toughness plotted over rings per inch by one inch classes.

tive factors and while rings per inch is an excellent criterion of properties, it is good not because of its own effect as a quantitative factor but by reason of its close relationship with a qualitative factor or factors, such as fibril angle. The close relationship of rings per inch and fibril angle appears to hold true regardless of specific gravity or amount of wood substance. Even the occurrence of the structural abnormality of compression wood does not disturb this relationship, for in compression wood the rings are wide and the fibril angles are very large.

It is fortunate that rings per inch showed such strong relationships with the mechanical properties for it provides a powerful link between the production of the wood and its utilization. Rate of growth can easily be determined in standing trees by increment borings and thus can serve as a guide to make possible the control of wood quality by silvicultural methods. The control of strength in the growing tree may be illustrated by the use of the data in the diagram of modulus of rupture, Figure 6, from which Table 4 was derived.

Trees which have been planted, or established naturally in the open have central regions within the stems which are composed of wide-ringed weak wood developed before the crowns closed. During the period before crown closure, no control over mechanical properties can be exercised save that achieved by closer spacing of the trees at the time of establishment to restrict the production of this type of material by securing earlier closure of the crowns.

Using modulus of rupture for an example, if the trees in the stand are allowed to slow down in rate of growth after crown closure until there are 21 annual rings per inch of radius, it will take 10.5 years to produce each inch of growth in diameter. The modulus of rupture will be high, but if this rate of growth is maintained by only light thinnings, it will require 63 additional years to produce a 12-inch tree, assuming a 6-inch diameter at the time the rate of growth leveled off at 21 rings per inch. If it took 20 years to produce the 6-inch diameter, it would require a total of 83 years to produce a tree 12 inches in diameter inside the bark. This rate of growth, while productive of wood of high strength after crown closure becomes effective, might mean a prohibitively long rotation to produce the desired size of timber.

On the other hand, if thinnings were started when the reduction in rate of growth after crown closure reached 12 rings per inch, the modulus of rupture would be reduced only 1,500 pounds and it would require a total of only 56 years to produce a 12-inch tree. However, if heavy thinnings maintained open conditions in the stand and the early rapid rate of growth continued, large sizes would be produced in a few years, but quality production, from the standpoint of strength, would suffer.

This is, of course, a purely theoretical calculation, as many other factors would enter the picture in its application but it serves to illustrate the possibilities in the silvicultural control of mechanical properties. Red pine stands should be established as closely as practicable in order to restrict the weak central region and, beginning shortly after the crowns close, the thinning program should maintain in a uniform rate of growth which should be as slow as the economic objectives of the rotation will permit. When several sites are involved, the poorer sites from the standpoint of rate of growth will nevertheless tend to produce the highest quality of wood from the standpoint of strength, but will require the most carefully controlled thinning program.

Summary

Information on the relations between the mechanical properties of red pine and the factors which influence them is needed with the approach of thousands of acres of plantations of this species to the stage when cultural measures are imperative.

In order to study these relations, nine temporary sample plots were established covering the range of site classes of Connecticut red pine plantations. The trees were selected to cover the range of diameter classes within each plot; within each tree a series of 0.75 by 0.75-inch specimens were prepared from both the north and the south radius of 4.5-foot bolts cut at breast height.

Static bending, compression parallel to the grain and toughness tests were run on the specimens and the values for modulus of rupture, fiber stress at proportional limit, modulus of elasticity, maximum crushing strength and toughness were computed. All values with the exception of those for toughness were adjusted to 12 percent moisture content.

Average values for the physical properties of all 88 trees and all specimens were compared with those of old-growth red pine. These values were found to be materially lower than those of the old-growth trees due to the rapid rate of early growth of the plantation trees.

Determinations of the average radial width of tracheids, thickness of cell walls, and alinement of the fibrils with the horizontal axes of the cells were made on 51 sample beams, selected on the basis of their positions with reference to mean lines drawn through scatter diagrams of modulus of rupture and modulus of elasticity plotted over specific gravity.

A detailed statistical analysis was made of the relations between modulus of rupture, fiber stress at proportional limit and modulus of

TABLE 4.—THE RELATIONSHIP OF RATE OF GROWTH AND MODULUS OF RUPTURE

Rings per inch	Modulus of rupture	Years to produce one inch of growth in diameter	Inches of diameter growth per year
	(lbs. per sq. in.)		
3	6,500	1.5	0.667
12	10,500	6.0	0.167
21	12,000	10.5	0.095

elasticity, and the influencing factors of site index, trees, orientation within the trunk, position of specimen in the radius, amount of summerwood, rate of growth, and specific gravity.

A second statistical analysis was made of the relations between the mechanical properties of maximum crushing strength and toughness with the influencing factors of rate of growth, amount of summerwood and specific gravity. A third analysis was made of the relations between the mechanical properties of cross-breaking strength and stiffness, and the influencing factors of rate of growth, amount of wood substance and alinement of fibrils.

Conclusions

1.—Orientation of the specimen within the tree (north or south) and amount of wood substance on the radial surface do not have significant effects upon modulus of rupture, fiber stress at proportional limit, or modulus of elasticity.

2.—Amount of summerwood on the cross-section has a significant effect only upon toughness of all the mechanical properties measured.

3.—Site, the individual tree, and position within the radius significantly affect the mechanical properties of the static bending test.

4.—Specific gravity does not have a significant effect upon the mechanical properties within sites and does not have as strong an effect as rings per inch when the effects of several sites are involved.

5.—Rings per inch has a strong effect upon all of the mechanical properties measured except that of fiber stress at proportional limit.

6.—Fibril angle, even on the basis of the limited number of specimens in the analysis, has a very strong effect upon both cross-breaking strength and stiffness.

7.—Red pine stands should be established as densely as practicable and, following crown closure, the thinning program should maintain growth at about 12 rings per inch for the production of wood with high strength values within a short period of years for the size desired.

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Pulpwood Cuttings in the Poorer Hardwood Sites of New Jersey

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MARKETS for a variety of forest products exist in nearly all areas of the northeastern states. Integrating these markets with constructive forest management is the job of practicing foresters, of wood-using experts, and of industry. In working toward this end, foresters should always bear in mind that our present complex economy was established many years before the active forestry movement developed, and if management is to be applied on a practical basis it must be adapted to and integrated with the economics of the wood-using industries.

The coordination of forest management on private lands with the wood-using industries was begun formally in New Jersey in 1938. The original program provided for the marking of woodlands by state foresters and the sale of the marked trees by private individuals called timber agents.[1,2] Having been proved successful, the system has been expanded into a cooperative effort in which the State Department of Conservation and Development, the Soil Conservation Service, the U. S. Forest Service, and the State Extension Service all participate. However, the program was concerned only with major forest products such as sawtimber, piling, and furnace poles, which were harvested toward the end of the rotation and did not provide for intermediate cuttings of small-sized materials in stands of younger age. The basic objective and unit of management in New Jersey is the even-aged stand, and if thinnings could be made at a profit during the pulpwood stage the rotation period of the final crop would be shortened and the practice of forestry advanced. Improvement cuttings to remove culls and weed species after woodlots have been high-graded would also be silviculturally helpful by providing more favorable conditions for desirable reproduction. The development of a local market for small products offered an opportunity for introducing these intermediate cultural operations in the New Jersey program.

A number of years ago several small pulp mills, producing a heavy felt for roofing and siding compositions, became established in New Jersey. These mills use both pine and hardwoods. None of these concerns operates company cutting crews; they rely entirely upon jobbers to keep them supplied with wood. The jobbers are small operators and have very little equipment. Although one-man chain saws are used to some extent, most of the wood is cut with a poll axe, and anyone with a saw, axe, and truck can qualify as an operator. One company utilizes 80 such jobbers, although all do not operate at the same time. Many of them work only in the fall and winter, and in summer turn to farm work.

The largest of the pulp mills consumes approximately 500 cords per week, and in 1947 arrangements were made with the purchasing agent to try out one cutting crew on a woodlot which had been marked for a pulpwood thinning. This proved so satisfactory that the company soon began referring other jobbers to the forestry agencies, and at present approximately one-third of its total wood supplies come from marked woodlots.

Marking is done with paint guns. The paint guns are "calibrated" by determining the number of trees that can be spotted at d.b.h. and stump for each gun full of paint. The volume marked is obtained by estimating the average d.b.h., and from volume tables the number of such trees per cord. To this figure the number of trees marked is applied. Pulpwood is bought by weight and the current price for thinnings is 70 cents per ton on the stump, equivalent to about $1.60 per standard cord. Payment is made on the basis of weight slips issued at the pulp mill when the jobber weighs-in. All cutting is performed under the terms of a written contract.

The usual method of handling pulpwood in southern Jersey is to buck the tree into bolts where it falls, drive a truck up, and load by hand. A straight-body two-axle truck with conventional rear drive is most commonly used. In some cases, this type of truck will pick up the wood and haul it to a good road where it will be reloaded on a truck-trailer. Experience has shown that under the cutting methods used, a minimum of six cords per acre must be marked in order to make an operation economically feasible. This can usually be obtained by spreading the marking over the trees from 4 to 9 inches d.b.h.

The woodlots in which most pulpwood thinnings have been made are the poorest of the upland oak sites, and in stands 60 years of age or older. Two such tracts have been selected to show the silvicultural conditions under which the work is done. The two stands were similar in form, and originally consisted of an overstory of chestnut with a secondary stand of white, black, scarlet, and rock oaks. Other species present were hickory, black gum, sassafras, and beech. Both stands were fully stocked. Following the death of the chestnut, the understory of oak became dominant, and it would appear that the heavier the overstory of chestnut had been, the poorer is the quality of the oak stand which succeeded it. Damage by black ants, and such defects as heart rot and ring shake were common. Cankers and galls were present on most of the scarlet oaks.

The soils on both areas are loamy sands of coastal plain origin with a high percentage of gravel on the surface and in the subsoils. Drainage is good but on the droughty side. Both are highly acid (pH

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about 4.0), and poor type humus is present on the surface. The understory consists of huckleberry, blueberry, mountain laurel, and green brier.

The improvement cutting salvaged the worst of the defective material and opened up the crowns for the purpose of encouraging natural regeneration. In marking, an effort was made to apply the D + X rule[3] with 12 feet as the spacing interval. Nine cords per acre were removed from the first stand and eight from the second, with net financial yields of $14.40 and $12.80 per acre, respectively. The residual stands consist entirely of dominants and codominants, and 3 years after the cutting a satisfactory amount of new oak reproduction had become established in the openings. Table 1 gives a description of the two stands after cutting.

TABLE 1. DESCRIPTIONS OF RESIDUAL STANDS

Stand	Age	Height of average dominant	Trees per acre	Average d.b.h.	Basal area per acre	Total volume left per acre: Trees over 12 inches d.b.h.	Total volume left per acre: Trees under 12 inches
	Years	*Feet*	*Number*	*Inches*	*Sq. ft.*	*Bd. ft.*	*Cords*
1	64	69	90	10.7	56.78	4540+	7.3
2	65	69	77	11.2	52.81	3380+	10.0

It is obviously desirable from the standpoint of management to replace stands of this kind with more healthy and vigorous ones as quickly as possible. The pulpwood market apparently will make it practicable to do this. The management plans call for removal of the residual stands in two operations over the next 10 to 20 year period, and since the least desirable stems have already been eliminated at a net profit of $12 to $15 per acre, it seems probable that this objective can be readily achieved. On sites of this class, rotations of not over 80 years would seem desirable, with a pulpwood thinning at about 35 years of age, another at 50, the first shelterwood cutting at 70, and the final one at 80 years. Such woodlots should definitely find a niche in the forest management program in New Jersey.

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Good Growth from Well-Stocked Longleaf Stands

If properly managed, well-stocked stands of second-growth longleaf pine can approach, in about 70 years, the volume of timber that the virgin stands laid on in two centuries.

This is suggested by a study on a 35-year-old longleaf forest on a good site in south Mississippi. The stand, which seeded in about 1912, was entirely without protection until 1923. Since then the area has been burned by two wildfires and grazed intermittently by cattle. In 1928 many of the trees had not yet started height growth, and few contained merchantable products. Stocking averaged 684 trees per acre.

In 1947 there were 488 trees per acre; most of them were of pulpwood size, many were 9 inches d.b.h., and the largest were 14 inches. Those in the main crown canopy averaged nearly 70 feet tall. Most of the trees that died before 1947 were too small to be merchantable. The merchantable trees (about 400 per acre) had averaged 2 cords of growth per acre annually since 1938. Total volume in such trees was 40 cords of unpeeled wood per acre. If each tree had been sold for the products it was best suited for (mostly poles or pulpwood), the stumpage receipts would have been about $100 per acre.

The first thinning was made in 1947. Up to that time growth had been satisfactory and competition had produced smooth, straight stems. Henceforth thinnings will be made about every 5 years, and 75 or 100 per acre of the best trees will be held for final harvest at about 70 years. In 1947 the stand averaged 8,000 board feet (Int. ¼-inch rule) per acre in trees 9 inches d.b.h. and larger. With thinnings, growth in the next 35 years should be at least 400 board feet per acre per year. If so, the total yield for the rotation will be about 22,000 board feet per acre, an amount that compares well with the better original stands.

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Some Effects of Cross-Pollination on Seed Production and Hybrid Vigor of Tuliptree

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TULIPTREE, *Liriodendron tulipifera L.* is one of the most useful and beautiful of all deciduous forest trees. It is the tallest of native hardwoods, attaining a maximum height of 198 feet and a maximum diameter of 12 feet (*4*).

This species, although very gregarious after initial establishment, is seldom found in pure stands and very seldom occupies a prominent position of abundance in any stand in Indiana. Potzger and Friesner quote a frequency index of 16 for tuliptree in a typical Indiana woods (*5*).

This study is an attempt to determine if the low viability of tuliptree seed is due, at least in part, to the continual selfing of the flowers and also to determine if any hybrid vigor can be induced into seedlings by cross-pollination.

Most of the pollination of this species is occasioned by bees. It was observed that the bees worked on a single tree, going from flower to flower on the same plant. The hypothesis drawn from these observations was that the trees which are largely self-pollinated produce aborted seed and consequently develop poor seedlings.

A study was made to determine if cross-pollination would increase the germination percent of the seed. The seed produced as a result of these crosses were grown in a greenhouse and compared with open-pollinated seed from the parents to determine if any hybrid vigor results from cross-pollination. The experiment was carried out over a period of 2 years to obtain the results of two seed crops.

Recently Duffield (*1*) found that controlled cross-pollination within the species *Pseudotsuga taxifolia* gave a high yield of sound seed much higher than uncontrolled wind pollination. Secondly, the self-pollinations made on one tree yielded no sound seed and relatively few hollow seed.

Wean and Guard (*7*), in a study of the seed quality in tuliptree found normal embryos in approximately 19 percent of the seed. A comparison of the size of filled and unfilled seed led them to postulate that a probable cause of low viability was abortion of the developing embryo.

Guard and Wean (*2*) also conducted studies to determine if the vigor, age, or site condition of the parent trees had a significant effect on the germinative capacity of the seed. They found that soil

FIG. 1. Semi-opened bud; correct stage of development for shipment.

fertility, within ordinary limits, is not a significant factor in determining seed quality. Germinative capacity was 15 percent in seed from trees larger than 15 inches d.b.h., and 20 percent in seed from smaller trees.

Guard (*3*), in a further study of causes of failure of seed development in tuliptrees, found indications that self-sterility may be in part responsible for low viability. He found that self-pollination resulted in 11.7 percent of filled seeds while controlled cross-pollination produced 38.9 percent of filled seeds.

The low germinative capacity of tuliptree seed has long been known, but the reasons for this are not completely understood. The many references to the germination percent of tuliptree all cite very low figures, ranging from 0 to 30 percent. Toumey (*6*) lists 10 to 20 percent as the accepted figure on germinative capacity for tuliptree.

Selection of Trees

Suitable trees for pollination experiments were selected in Tippecanoe County, Indiana, during the spring of 1948 and 1949. They were vigorous, open-grown, mature trees which had good flower-bud development. Open-grown trees were selected because they have healthy living branches near the ground. Flowering branches of tuliptree in woods competition are usually produced above the forest canopy.

The work done in the spring of 1948 was performed on three trees separated from each other by a distance of about 12 miles. The second season's work was performed on different trees and the distances between the trees were increased.

Pollen Shipment

Handling and shipping pollen was one of the most difficult phases of the experiment. It was found that pollen which was collected and stored for 14 hours at normal laboratory temperature was not viable. Pollen had to be collected and used immediately if successful crosses were to be expected. Shipping free pollen from long distances was not tried for this reason. The shipment of pollen-bearing flowers is very satisfactory if proper care is taken in packaging and shipping. The flower buds were collected at the right stage of development (Fig. 1) and shipped immediately. In packing the flowers for shipment, all leaves were removed to prevent internal competition for water. The flower stems were cut to 3 inches in length, and each flower was wrap-

ped individually in dry newspaper. The wrapped flowers were tightly packed in a cardboard box and sent air mail, special delivery. This method of pollen shipment has been tried several times and has given excellent results.

Several methods of pollen removal were tried, and the best and most complete method found will be described. The flowers were collected early in the morning, when the petals were just beginning to separate at the tip of the flower. In this condition the flowers were taken to the field in a vasculum, and the pollen removed from the anthers just prior to pollinating. To remove the pollen it was necessary to locate the line of dehiscence of the anther. Tuliptree pollen sacs run longitudinally for the full length of the anther. By placing the end of a blunt teasing needle in the groove, made by the line of dehiscence, the entire pollen sac can be opened and scraped in one operation.

Tuliptree pollen is sticky, and when scraped out forms a small moist ball which is placed in a watch glass and covered. There are from 18 to 30 anthers per flower, which will yield enough pollen for five crosses if carefully collected and sparingly applied. The scraping method is far superior to brushing the pollen from completely dehisced anthers, since it gets all the pollen when it is viable. Observations of pollen from dehisced anthers revealed that many of the grains had germinated in the anther. This would, of course, lower the amount of viable pollen that could be removed by brushing.

Flowers to be pollinated must be emasculated, to prevent self-pollination. There is a certain stage of floral development which is best for emasculating and pollinating. A flower which is ready for pollination should have lost its bracts, be soft, and almost open. Flowers in this condition can be found only in the morning, since by afternoon they will have opened. Once the flowers have opened on the tree, insects enter them and cause uncontrolled pollination. Flowers that are just ready to open can be opened by forcing the petals apart. If the pistil is in good condition, the flower is emasculated (Fig. 2). In tuliptree the gynecium consists of many individual spirally arranged pistils on a central axis. Below the cone-like gynecium there

FIG. 2. Emasculated flower, ready for pollination. (In actual pollination the petals and sepals are disturbed as little as possible.)

are twenty to thirty spirally arranged single anthers. These anthers are removed by pinching off the filaments near the base. Care must be exercised in removing the anthers not to damage the pistil.

When the flower has been prepared for pollination by opening and emasculating, it is pollinated by brushing the collected pollen on the pistil.

Immediately after pollinating the flowers, it is necessary to cover them with paper bags to prevent uncontrolled insect pollination. This is done by placing ordinary number 10 Kraft paper bags over the flowers and fastening them securely to the floral branches with fine steel wire. They prevent entry of insects, and are porous enough to prevent undue condensation. Rain does not destroy them, and the wind will not remove them. After bagging, each cross-pollinated flower is marked with an identifying tag. The most successful marking tags found were ordinary Railway Express tags with reinforced eyelets and wire attached. The surplus wire was used for securing the bags in place, and the remaining wire was looped around the floral branch to hold the tag in place. The tags were marked with soft graphite pencil to record the parents of the cross and the date of pollinating. The tags were cut with an identifying mark, as an insurance against the obliteration of the pencil markings.

The bags were removed from the flowers after 3 weeks. If pollination was successful the pistils were two to three times as large as they were at the time of pollination.

When the fruits reached maturity, about the first of October, they were collected while still green and air-dried until the carpels separated from the central axis.

Stratification

A stratification schedule of 90 days was used, which was long enough to insure normal seed germination. The seed was stratified in river sand out-of-doors under 8 inches of gravel. Each lot of seed was placed in a tightly closed cloth bag before covering with sand. The bags were buried in flats of moist river sand and sunk in the soil. The cloth bags were porous enough to allow good aeration and water penetration. After covering the flats with gravel, copious watering was carried on for 2 weeks and then the flats were left unattended until removal in February. The temperature of the seed averaged somewhat above the air temperature and was seldom below freezing.

Growth and Development of Seedlings

The stratified seed were sown in 6-inch clay pots in an equal mixture of river sand, clay, and peat. The mixture was first sterilized by saturation with a 10-percent commercial formalin solution. Ten seeds were planted per pot about $\frac{1}{4}$ inch below the surface. Germination counts were made periodically and after 2 months all pots were thinned to one plant per pot.

After thinning, there was a period of adjustment during which little apparent growth took place.

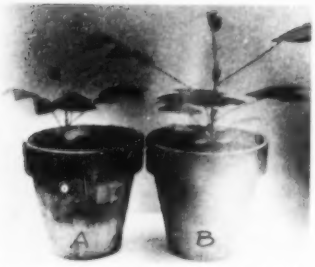

FIG. 3. Comparison of total height growth at end of 4 months. A open-pollinated, B cross-pollinated.

In 10 days the characteristic valvate terminal bud developed, and the seedlings produced their first juvenile leaves.

For the next 6 weeks the growth above ground was almost static, except for enlargement of the terminal bud. The plants seemed to stop growth when they had put out the cotyledons and two juvenile leaves. After the third month, however, shoot growth began and the plants continued a period of very rapid elongation.

During the fourth month of growth a serious infestation of red spider developed on the seedlings. An oil emulsion was tried, which, although it did not harm the seedlings, did not kill the red spiders. A relatively new insecticide (Parathyon),[3] applied at 3-week intervals, was completely successful in killing all the insects in the greenhouse as well as the red spiders.

By the end of the fifth month, some of the hybrid seedlings had attained a height of 300 mm. and had developed fourteen foliage leaves. There was no apparent cessation of growth until the plants were hardened off for the winter late in September by withholding water.

By the end of the fourth month, evidence of hybrid vigor became apparent (Figs. 3 and 4). There was a wide variation in the size of all seedlings, both open-pollinated and crossed, but the largest were from the crosses. The largest seedling from a cross was almost twice the height of the largest open-pollinated plant.

[3] Supplied by courtesy of American Cyanamid Corp., New York.

Results and Discussion

Cutting of seed and germination counts indicate a marked increase in the percent of filled seed and germinative capacity due to cross pollination (Fig. 5).

The percent of filled seed in Cross A × C was 90 percent, while the highest open-pollinated tree (Tree A) produced only 34.8 percent filled seed. Germination tests run on the same material showed that about 60 percent of the filled seed will germinate.

Figure 6 shows the average total height of the seedlings produced by cross pollination and open pollination. There was a definite indication of heterosis shown here, since the average total height of the crosses was consistently greater than the average total height of open-pollinated seedlings. The more distant pollen produced the greatest increase in vigor. It was found that reciprocal crosses gave almost uniform increases in vigor.

This experiment shows definite promise for producing high-quality tuliptree seed. Under present methods it would make the seed very expensive, but techniques might be worked out to cut the cost of production.

In producing nursery stock for distribution, if seed source were considered and each shipment of nursery stock contained a mixture of seedlings from several seed sources, there is a possibility of producing the hybrid seed naturally. If the nursery stock reaches maturity and the stand is at all dense, the bees would tend to cross pollinate these racial strains. The resulting seed would have a higher germinative capacity and the seedlings would exhibit heterosis. It is not recommended that too wide a latitude of seed source be used since this presents problems of seedling establishment and growth.

FIG. 4. Comparison of total plant size at end of 4 months. Left, cross-pollinated; right, open-pollinated.

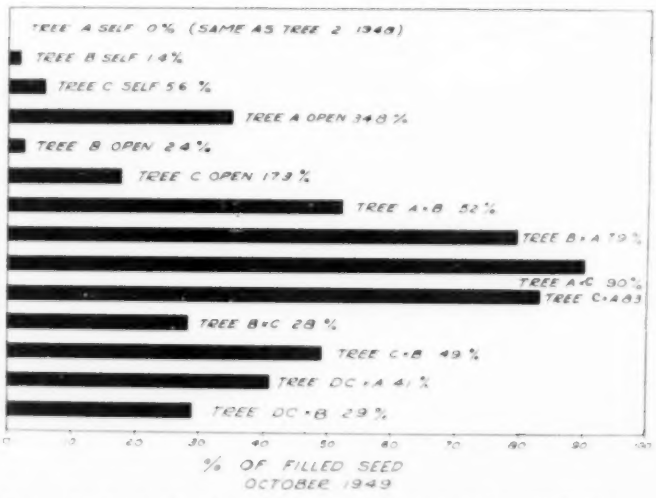

FIG. 5. Results of cutting test of 4,200 samaras from open and cross pollination.

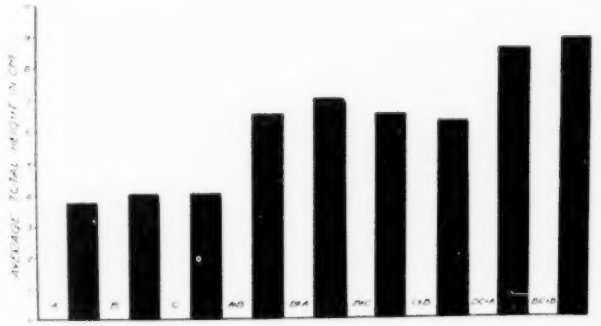

FIG. 6.—Average total height growth of hybrid and open pollinated seedlings at end of 4-month growing period.

However, it has been shown that better seed and seedlings can be obtained by crossing trees separated from each other by a distance of 10 miles.

Summary

1. Viable pollen of *Liriodendron tulipifera* for cross-breeding can be successfully shipped anywhere within the natural range of this species.

2. Pollen is best shipped in the anthers of fresh whole flowers via airmail special delivery.

3. Cross-pollination increased the percent of filled seed per cone.

4. Self-pollination greatly reduced the percent of filled seed and in some cases there was complete sterility.

5. A stratification schedule of 90 days in moist river sand at temperatures of 36 to 40 degrees F. proved entirely satisfactory.

6. Seedlings produced as a result of cross-pollination tended to be more vigorous than seedlings resulting from normal open-pollination.

7. These experiments indicate that it may be possible by planting mixed nursery stock from widely separated seed parents to obtain populations of different genetic constitution which would result in improved germinative capacity of the seed and more vigorous seedlings.

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Pine Growth Doubled by Improvement Cutting

Two years after they were released from overtopping hardwoods, young shortleaf and loblolly pines near Birmingham, Ala. have nearly doubled their annual height growth.

The pines, which are less than 2 inches d.b.h., are in a stand averaging about 1,600 desirable seedlings per acre. The original stand contained 49 square feet per acre of basal area in trees more than 1.5 inches d.b.h., mostly in undesirable hardwoods. A heavy improvement cutting in 1947 removed all undesirable trees more than 1.5 inches d.b.h.—a total of 39 square feet of basal area per acre, or 80 percent of the original stand.

Shortleaf and loblolly pine responded about equally well to release. Average annual height growth was $8\frac{1}{2}$ inches before treatment and 16 inches the second year after. In the first year after release, however, growth was only 8 inches. The released trees evidently required one year in which to develop vigorous crowns before starting better height growth. The growth of similar pines that were not released dropped from $6\frac{1}{2}$ inches in 1947 to $4\frac{1}{2}$ inches in 1948 and 1949.

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Grazing of Forest Lands in Interior British Columbia[1]

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Grazing by livestock is an important use of certain forest types in interior British Columbia. These lands produce palatable and nutritious forage for summer grazing, supplementing the limited amount of spring-fall grassland range. These forests are adapted for multiple use, with grazing fitting well into a pattern which includes watershed maintenance, logging, wildlife, and recreation. The future of forest grazing in the region is complicated by fire protection policies since the best ranges are under sub-climax forest stands which owe their presence to fires.

THE GRAZING of domestic livestock has been recognized for some time as an important phase of multiple land use in certain forest types. In the western United States, the relatively open forests of the Intermountain Region, and of the eastern slopes of the Cascades and the Rockies provide summer grazing for large numbers of cattle and sheep. Not so well known are the forest grazing areas of western Canada, which although smaller in extent than those farther south, play a similar role and present similar problems. The forested grazing lands of western Canada occur mainly in two regions, interior British Columbia and the eastern foothills of the Rocky Mountains in Alberta. This paper deals with the grazing resources of the former area.

Although forests in interior British Columbia have been used for livestock grazing since the 1890's, virtually no detailed study was given to the range value of these lands until quite recently. The establishment of a Dominion range experimental sub-station at Kamloops in 1935 marked the beginning of range research in the region, while the range survey program of the provincial government is almost as recent in origin. The data presented here are based on studies made during the period 1935-40 when the Kamloops Station was active and again in 1946-47 when some of the projects were resumed. The author was engaged in range research in the region during this period.

The region under discussion is a large one, bounded by the Rocky and Columbia mountain systems on the east and the Coast Range on the west. The main portion extends northward from the international boundary about 400 miles, to Latitude 54, just north of the towns of Prince George and Vanderhoof. The width of this part varies greatly, averaging about 200 miles. An additional area containing forest grazing types occurs in the Peace River area in the northwest corner of the province (Fig. 1).

The topography is rugged, with the major part of the region occupied by a series of irregular plateaus separated by broad, deep valleys. The relief is most pronounced in the southern portion, becoming much less as one proceeds north. The general plateau level is approximately 5,000 feet above sea level in the southern part of the region, decreasing northward to a minimum of 2,200 feet in the vicinity of Prince George. Drainage is mainly to the west by way of the Fraser River and its many tributaries, but the southwestern corner drains into the Columbia River. Further information on physiography is available in a recent paper by Brink and Farstad (*1*).

The climate varies greatly in response to differences in altitude, exposure, and latitude. Data from

Fig. 1. Outline map showing approximate extent of forest grazing types in interior British Columbia. The grassland areas which occupy the main valleys of the southern portion are not shown.

[1] Presented at a meeting of the Division of Range Management, Society of American Foresters, Seattle, Wash., October 12, 1949.

[2] The author is indebted to Mr. W. G. Pendray of the British Columbia Forest Service for information concerning range administration areas, and livestock numbers.

TABLE 1.—CLIMATIC DATA FOR STATIONS IN INTERIOR BRITISH COLUMBIA

Station	Altitude	Latitude	Average precipitation		Mean temp.	
			Annual	Apr.-Sept.	Jan.	July
	Feet	*Degrees*	*Inches*	*Inches*	*Degrees F.*	*Degrees F.*
Kamloops	1,138	51	10.1	5.5	22	70
Knouff Lake	3,750	51	14.8	7.7	No record	
Hedley	1,700	49	11.7	5.8	22	68
McCulloch	4,100	50	26.1	11.4	4	55
Quesnel	1,750	53	16.1	8.6	15	62

a few representative stations are presented in Table 1.

Kamloops is representative of the grassland areas. Hedley is in ponderosa pine, while Knouff Lake is in the Douglas-fir zone and McCulloch in the spruce-fir type. The data from these stations illustrate the vertical zonation so characteristic of the southern interior. Quesnel is situated farther north, where the Douglas-fir zone occurs at lower altitudes. Most of the forest grazing is in areas with a mean annual precipitation of 12 to 16 inches.

The soils of the area are derived mainly from glacial drift, since the whole region was glaciated during the Pleistocene. Classification and survey of the forest soils is far from complete (*1*), but results to date indicate the presence of several zonal podsolic types as well as the pedacol-like soils of open ponderosa pine stands. Depth and texture vary, but over most of the region the soil mantle is sufficiently fine and deep to support vigorous plant growth.

The natural vegetation reflects the great variation in topography, climate, and soils. Forest occupies 95 percent of the region, with grassland and alpine tundra making up the remainder. The grasslands are restricted to the main valley and adjoining slopes, while forest covers the plateaus and the lower mountain tops. The forests constitute part of the Rocky Mountain coniferous complex, and include three major zonal types. The grasslands are of the bunchgrass type, closely related to the Palouse Prairie of Washington, Oregon, and Idaho. Vertical zonation is marked, so that several vegetational zones commonly occur within a distance of a few miles (*5*).

By no means all of the forested area is used for livestock grazing, although most of the drier and more open types have range value. Of an estimated 10 to 15 million acres of usable forest range, about 7 million are now grazed (*3*). The amount of forest range is not a critical factor over most of the area, since winter feed supplies and the amount of grassland for spring-fall use ordinarily limit the range livestock population.

During 1948 a total of 117,000 cattle and 32,000 sheep were grazed under permit on provincial forest ranges. The total number of stock using forest grazing land is greater than this, but reliable figures are not available.

Forest Zones

The three main forest zones in the interior are the ponderosa pine, Douglas-fir, and spruce-fir. The ponderosa pine type is the smallest of the three, forming a relatively narrow fringe along the upper edge of the grasslands, below the Douglas-fir zone. The pine type is limited to the southern interior, not extending north of Latitude 51. Except for some immature stands, the tree cover in this zone is relatively open and supports a well developed ground cover. The herbaceous vegetation includes many of the same species of grasses and forbs which are found on the adjacent grasslands. The principal forage plants include bluebunch wheatgrass (*Agropyron spicatum* Pursh), June-grass (*Koeleria cristata* (L.) Pers.), and rough fescue (*Festuca scabrella* Torr.). Only in southeastern British Columbia, in the East Kootenay area, does one find the shrubby ground cover characteristic of the ponderosa pine zone in northern Idaho and northwestern Montana.

From the grazing viewpoint, this zone is similar to the grasslands, providing forage of the bunchgrass type for spring and fall use. The forage yield is much the same as for the wheatgrass-bluegrass grassland type, with a grazing capacity of about 2.5 acres per animal unit month when in good condition.

The most important of the forest types from the grazing standpoint is the Douglas-fir. The zone northward to about Latitude 53, some 300 miles north of the United States border, and occupies the lower plateaus and upper valley slopes of the southern and central interior. At higher altitudes and more northerly latitudes it is replaced by the spruce-fir zone. Douglas-fir (*Pseudotsuga taxifolia* (Lamb) Brit.) is the climax dominant, and in areas protected from frequent fires it often forms almost pure stands (Fig. 2). The mature tree cover is relatively open except on favored sites, but the reproduction tends to be fairly dense.

Successive fires have affected the tree population greatly, so that only limited areas remain in Douglas-fir, most of the zone being occupied by a fire subclimax of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.), aspen (*Populus tremuloides* Michx.), and willow (*Salix* spp.). The aspen and willow are important chiefly in the early stages of the succession, rarely lasting more than one generation (Fig. 3). Lodgepole pine is more persistent, and over large areas where seed trees of Douglas-fir are now scarce, the pine forms a relatively permanent type.

The principal herbaceous species is pinegrass (*Calamagrostis rubescens* Buckl.), which is dominant over large areas, commonly composing 40 to 50 percent of the ground cover and 50 to 65 percent of the forage yield. Grasses of secondary importance include bromes (*Bromus* spp.), needle grasses (*Stipa* spp.), and a dwarf sedge (*Carex concinnoides* Mack.). The most abundant forbs are heartleaf arnica (*Arnica cordifolia* Hook.), strawberry (*Fragaria glauca* (Wats.) Rydb.), asters (*Aster conspicuus* Lindl. and other spp.), lupines (*Lupinus* spp.), and peavine (*Lathyrus ochroleucus* Hook.).

FIG. 2. Mature Douglas-fir type near Kamloops, British Columbia. Although the tree stand is relatively open, the forage cover is much inferior to that shown in Fig. 3.

Many other forbs occur, particularly under the more open forest covers.

The shrub cover is composed chiefly of dwarf to medium-sized forms, including bearberry (*Arctostaphylos Uva-ursi* Spreng.), twinflower (*Linnaea borealis* Holtz.), rose (*Rosa* spp.), and spiraea (*Spiraea lucida* Dougl.). Tall shrubs occurring commonly are Canada buffaloberry (*Elaeagnus canadensis* (L.) Nels.) and serviceberry (*Amelanchier florida* Lindl.).

The cover, vigor, and forage yield of the ground vegetation varies greatly, depending largely on the density and nature of the tree cover. Some idea of the differences in yield may be obtained from the data in Table 2.

It is evident that sites occupied by aspen were superior in amount of both total ground cover and yield of forage, while the Douglas-fir sites were poorest. The ground cover of the lodgepole pine stands was moderately productive in relation to density of tree cover. Further studies are needed to check these findings in other portions of interior British Columbia, but the evidence at hand suggests that the situation indicated above is typical for the zone.

Grazing use in this zone is restricted to the summer season, usually from mid-June to the end of September. During this period, livestock will make satisfactory gains, but attempts to prolong the season of use are likely to be unsatisfactory both for the range and the animals. Studies made at the Kamloop Station from 1938 to 1940 show that 2-year-old steers and heifers made gains averaging 2 pounds per head per day during late June, July, and August (6). Gains were reduced sharply after that, averaging 1 pound per day or less in September, while slight losses of weight actually occurred with stock held in the zone during October. The Douglas-fir zone is of great value in providing a period of rest for the grasslands, but obviously cannot take over their function as spring and fall range.

The spruce-fir zone occupies large areas at higher altitudes in the southern and central interior and becomes the principal type north of Latitude 53. The climax dominants, Engelmann spruce (*Picea Engelmanni* Parry) and alpine fir (*Abies lasiocarpa* (Hook.) Nutt.) commonly form rather dense stands, and this combined with the short growing season inhibits the development of an undercover of grazing value. Typically the ground vegetation is dominated by low shrubs, principally species of *Vaccinium*, and by a mat of mosses and lichens. Species palatable to livestock are of little importance.

The principal grazing value of this zone lies in (1) the numerous natural meadows which abound in certain portions, (2) the more open cover-type occurring near timberline, and (3) burned-over areas. The first two sub-types furnish considerable forage in the main interior grazing area. Burned sites are of importance chiefly in districts in the northern part of the region, where a mixed farming and grazing economy exists.

The season of use for the zone is short, being confined usually to a period of 2 or 2½ months in midsummer. Forage yield and grazing capacity vary greatly and reliable data are not available.

Grazing and other Land Uses

In interior British Columbia, as in forested and mountainous areas generally, livestock grazing has to fit into a pattern of multiple use. Watershed maintenance, timber production, wildlife, and recreation are all important parts of this pattern in the region under discussion.

Watershed maintenance is of vital concern, since cultivated agriculture in the southern and south-central interior is largely depend-

TABLE 2. YIELDS OF GROUND COVER VEGETATION FROM DIFFERENT TREE COVER TYPES DOUGLAS-FIR ZONE, KAMLOOPS, 1947[1]

Tree cover type	Yield (lbs. dry matter per acre)		
	Palatable	*Unpalatable*	*Total*
Aspen	623	23	646
Lodgepole pine	293	122	415
Mixed stands[2]	219	17	336
Douglas-fir, mature	155	17	172
Douglas-fir, young	98	4	102

[1] Data from Tisdale.
[2] Mixtures of Douglas-fir, lodgepole pine, and aspen.

cut on irrigation. Some 70,000 acres are now irrigated, chiefly in the main valleys. The potential irrigated area is probably double the present amount. Most of the irrigation water is local run-off, from the Douglas-fir, spruce-fir, and alpine zones. Improper grazing of key watersheds could have serious results on the water supply for both agricultural and urban use. Not much trouble has been encountered to date, but grazing use of many watersheds is relatively recent, and long-term effects are still to be experienced.

Forest production, although on a scale smaller than in the coastal region is an important land use in interior British Columbia. The annual report of the British Columbia Forest Service for 1948 lists the total number of sawmills in the interior as 986, with an aggregate daily capacity of approximately 8.5 million board feet. In addition, there is a considerable production of railroad ties, cordwood, and poles. Spruce, Douglas-fir, and ponderosa pine are the chief merchantable species. The total annual cut is below the sustained yield capacity, but there is overcutting in some areas and types. Fire and insects probably take as great an annual toll as does the industry.

Due to the moderate cut, and to the fact that the most productive timber sites are usually out of the best grazing areas, there is relatively little conflict between logging and grazing use. The available data indicate that moderate grazing is not detrimental to reproduction or growth of the coniferous trees. Aspen is more affected by grazing, but does not rank as a commercial species in this region. In general, logging operations tend to increase grazing capacity for a few years, but later the growth of forage is usually much reduced by tree reproduction.

The forests of the interior support large populations of deer, moose, bear, and grouse, while the numerous lakes and streams are well-stocked with game fish. The large native grazing animals spend the summers mainly in the higher

FIG. 3.—Desirable forage cover under 50 year old stand of aspen. Note the vigorous reproduction of Douglas fir. Barring further fires, the latter species is almost certain to dominate the site in a few decades with a resulting decline in grazing value.

forest areas and do not compete much with livestock. The main zone of competition is at the lower edge of the forest, where the normal winter range of the deer is used also as spring-fall pasturage by domestic stock. The problems involved here are likely to increase as land use becomes more intensive and may require adjustments in grazing areas and or numbers of both game and livestock.

Recreational use is still light over most of the region, so that there is little or no need to restrict grazing on this account. Pressures along this line are likely to increase with population growth and increased tourist activity.

Problems of Forest Grazing

The presence of an adequate amount of forested range for summer use does not mean that there are no difficulties involved in the correct utilization of the resource. Problems have been met already, and doubtless others will develop as grazing use continues and is intensified in some areas. As in the western United States, the problem of proper distribution of livestock on rough, timbered ranges is of prime importance. Increasing application of proven management practices including riding, salting, water development, and fencing is doing much to secure better range use. Two other problems receiving considerable attention at present are (1) accessibility of ranges and (2) invasion of open or lightly timbered ranges by forest growth.

Accessibility of range is a serious matter, especially in the Douglas-fir zone. Here many stands of middle-aged and mature lodgepole pine have been killed in recent years by bark beetles (*Dendroctonus* and *Ips* spp.). As a result, large areas are covered by masses of fallen trees. Not only do these patches lose most of their grazing value due to the inability of stock to move about freely, but they often block the route to more desirable range areas. A program of trail clearing on the part of the provincial government and some individual ranchers is helping the trail situation, but no practical method has been found for clearing out the bug-killed areas themselves.

The invasion of open or semi-open areas by tree growth, with consequent reduction in grazing capacity and usefulness as early range is a common phenomenon over much of the interior. While this may be aided in some places

by heavy grazing, it seems to be mainly a natural return of trees to areas deforested in the past by repeated fires. Controlled burning has been advocated as a cure by many stockmen, and a few experimental burns are being made. The complexity of this problem as found in other grazing areas suggests that it is likely to be some time before the value of fire for range improvement in this region will be known.

The problem of fire in relation to forest ranges goes beyond a consideration of "bug-killed" and forest invasion areas. A large part of the present forest range is dominated by lodgepole pine and aspen, subclimax species whose present abundance is due to repeated fires in the past. With increasing fire control, a policy generally deemed desirable for silvicultural and watershed values, the climax Douglas-fir will gradually become reestablished as the dominant tree. Data now available (7) indicate that on the average, areas dominated by this species will be less productive of forage than they would be under stands of the subclimax trees. Since the change is not one which will come suddenly, it is not likely to cause any immediate dislocation of the range livestock industry, and future developments may reveal compensating factors. The fact remains that the best timber ranges in interior British Columbia today were made by fire, and any comprehensive land use policy for the future must take this fact into account.

Administration of Forest Grazing Lands

While some forested grazing lands are privately owned, the greater portion are on public domain, known as "Crown land." These lands are administered in a similar manner to that practiced on federal grazing lands in the United States. In Canada, however, the public domain, along with other natural resources, is the responsibility of the provincial governments rather than that of the federal authority. In British Columbia the public domain is administered by the Department of Lands and Forests, which includes the Forest Service.

Public lands used for grazing are divided for administrative purposes into grazing districts. Grazing use is on a permit basis, with both yearly and 10-year permits issued. Permittees in each grazing district are encouraged to form livestock associations which act in an advisory capacity for their district. The actual administration is in the hands of the district forest rangers and specialized range personnel of the department. Grazing fees are assessed on a basis of a monthly charge per head of stock. Formerly one-third of all grazing fees was used for range improvement purposes but this proportion was recently increased to one-half. Development of watering places, trails, and fences are major activities financed by this range improvement fund.

A range survey program is being carried on with an annual coverage of about a million acres a year. Adjustments in rates of stocking and in livestock distribution are being made in accordance with the conditions shown by these surveys.

General administrative objectives include maximum sustained use of the forage crop, maintenance of a proper balance between grazing and other forms of land use, protection of users of Crown lands against unfair grazing competition, and aid in building up the range livestock industry of the region.

Conclusion

On the whole, grazing fits readily into a multiple use program in forested areas of interior British Columbia. The main forest ranges are in those parts of the Douglas-fir zone which have the lowest potential for timber production, and moderate grazing does not appear inimical to watershed maintenance. Local adjustments will no doubt be necessary as development of the region and its resources continues, but the overall supply of summer grazing on forest lands appears likely to be sufficient to meet future demands.

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Thinning Over-Dense Jack Pine Seedling Stands in the Lake States

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BECAUSE JACK PINE, with its many unopened cones, commonly has a large seed supply, it often reproduces in very dense stands, some of which may contain more than 10,000 stems per acre. Such dense stands often originate after fires, but in some parts of the Lake States, particularly central Wisconsin, they may come in without fire.

These stands often stagnate or at best their growth is slow (Fig. 1). Moreover, as they grow older, periodic sleet, ice, and wet snowstorms often flatten sizable areas of the stands. Since the trees are usually too spindly to recover, the stands gradually develop into dense overstocked groups of trees of slow growth, intermixed with open areas. Thinning would, therefore, seem to be the answer needed to correct this condition. This naturally brings up the questions: When should such thinning be done and how heavy should it be? An opportunity to obtain basic data to answer these questions was provided by an over-dense stand of jack pine located on the Aurora Ranger District of the Superior National Forest in Minnesota.

This area of 150 acres originated from a direct seeding made on a very recent burn in early 1937. Because of a combination of circumstances (favorable weather, excellent seedbed conditions, and a were remeasured and the plots to seedling stand was too dense from the start. At the end of the first summer, stocking ranged from 6,700 to 33,000 seedlings per acre. Subsequent losses from natural mortality, although considerable, did not reduce the density enough to permit satisfactory growth. A tally made when the trees were 5 years old showed the stand to average 13,000 jack pine plus 4,600 aspen suckers per acre.

The combination of a large area of dense seedlings on a uniform site and the availability of labor from a Civilian Conservation Corps camp created a favorable situation for a thinning study designed to answer the questions of spacing and age. Accordingly, the Lake States Forest Experiment Station joined with the national forest in establishing such an experiment in the fall of 1941, when the stand was 5 years old and 4 to 5 feet tall. Within each of three separate blocks, half-acre plots were thinned to 4 by 4-, 6 by 6-, and 8 by 8-foot spacings, and additional plots were reserved for subsequent thinning at ages 10, 15, and 20 years. Each treatment as well as the control was replicated three times and the replications randomized within blocks. The thinning was done with "Finn hooks,"—knife-like tools formerly used locally for plantation release.

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FIG. 1. Unthinned stand of jack pine, 10 years old, Aurora seeding, Superior National Forest.

At the end of 5 years, the trees be treated when 10 years old were thinned. Treatments were the same as in 1941 except that the 8 by 8-foot spacing, which appeared to be too wide, was omitted. For this was substituted a crop-tree release in which all trees were cut within a 3-foot radius of crop trees spaced about 10 by 10 feet. The thinning, done by local woodsmen using 2¼-pound axes, required the following expenditure of time per acre:

4 by 4 foot spacing	4.22 man-days
6 by 6 foot spacing	4.75 man-days
Crop tree release	2.00 man-days

The 10-year thinning was thus cheaper than the original which cost 5 to 6 man-days per acre. Although the costs seem high for the heavier thinnings, it should be pointed out that 7,000 to 7,500 stems were cut per acre, and care had to be taken to preserve the experimental character of the test.

Results of 1941 Thinnings

Although the final answer will not be available for several years, the first 5-year remeasurement of the thinning plots gives considerable indication as to the proper density for young jack pine. In spite of high mortality, the unthinned stand still has 7,500 trees per acre—far too many. Losses on the thinned plots have been minor, amounting to about 10 percent of the trees for the 4 by 4 spacing and about 5 percent for each of the others (Table 1). Mortality on all plots has been due almost entirely to girdling by snowshoe hares. Suppression played a very minor part.

Basal area is higher in the unthinned stand than in the thinnings but the latter have a greater proportion of their basal area in the larger size classes (Table 2). For example, trees 3 inches and larger compose only 5 percent of the basal area of the unthinned stand, but 40 to 60 percent of the basal area on the thinned plots. As a result, commercial thinnings will be possible in thinned areas several years earlier than in the unthinned stand.

Although the two heavier thinnings have a considerably higher

[1] Three pounds of seed per acre were used; one pound would apparently have been sufficient.

TABLE 1.—STAND AND BASAL AREA PER ACRE[1] IN A 10-YEAR-OLD JACK PINE STAND 5 YEARS AFTER THINNING

Treatment	Number of trees 1941 Before thinning	1941 After thinning	1946 [2]	Basal area 1946	Average d.b.h. 1946
				Sq. ft.	*Inches*
None	10,500	10,500	7,533	84.2	1.4
4 by 4 feet	12,100	2,640	2,373	59.0	2.1
6 by 6 feet	13,100	1,210	1,156	44.1	2.3
8 by 8 feet	11,600	680	644	19.4	2.4

[1] Data averaged for three replications.
[2] Includes only trees 0.6 inch d.b.h. and over.
[3] Trees had no measurable basal area in 1941.

TABLE 2.—DISTRIBUTIONS OF NUMBER OF TREES AND BASAL AREA, BY D.B.H. CLASSES, IN PERCENT, 5 YEARS AFTER THINNING

D.b.h. class	Unthinned Number trees	Unthinned Basal area	4 × 4 feet Number trees	4 × 4 feet Basal area	6 × 6 feet Number trees	6 × 6 feet Basal area	8 × 8 feet Number trees	8 × 8 feet Basal area
Inches				*Percent*				
1	69	48	18	4	11	2	10	2
2	30	37	62	55	55	41	54	39
3	1	5	20	40	34	57	36	57
4	0	0	(1)	1	(1)	(1)	(1)	2
Total	100	100	100	100	100	100	100	100

[1] Less than ½ percent.

proportion of their basal area in trees 3 inches and larger, the 4 by 4 spacing has a much greater number of trees (Fig. 2). It would, therefore, seem that commercial thinning might be possible at an earlier date on the 4 by 4-foot spacing than on the wider ones where any early thinning would tend to deplete the growing stock. At least the greater number of trees on the 4 by 4 foot spacing would allow far more choice to be made in future thinning and would furnish considerable reserve for mortality.

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FIG. 2.—Ten-year-old jack pines thinned to 4 by 4 foot spacing when 5 years old.

Thinning has also had an appreciable effect on height growth and tree development. Increased spacing between trees resulted in slightly less height growth, but greater sturdiness. Although the 8 by 8-foot spacing shows the stockiest trees, these have very low crowns composed of rather coarse branches and appear somewhat like orchard trees. Those on the lightest thinning, although less sturdy, have better-formed crowns and seem more desirable.

Hares as a Thinning Agent

An interesting sidelight on the development of this over-dense jack pine has been the role of snowshoe hares (*Lepus americanus phaonotus*) in thinning the stand. During the winters of 1942-44, these animals did considerable nipping of the lower branches but this had little effect on the trees. As the stand grew taller, however, the lower branches died, and the only winter food available for the large hare population was the bark on the trunks of the trees. In the spring of 1945, the animals were found to have gnawed the bark in varying amounts from thousands of trees in the area. Additional girdling occurred during each of the next two winters, but ceased entirely in 1947-48.

At the time of the 1946 remeasurement, considerable data were collected on the amount of girdling and resultant mortality in relation to diameter and spacing. The results are rather striking (Table 3). As both diameter and spacing increase, girdling damage sharply decreases, presumably because of the preference of the hares for the more tender bark of the smaller trees, and of the lessening amount of protective cover afforded. That there is an actual preference for small trees is shown by the fact that the diameter distribution of girdled trees is not like that of the stand as a whole.

Death from girdling by hares likewise decreases as stem diameter increases. On the unthinned plots the animals in two winters killed 24 percent of the trees which were living in 1944-45; all trees killed by girdling were in the ½- and 1-inch classes. In the thinning as a whole only 3 percent had been killed in this manner. Hares, consequently, have been of considerable benefit in thinning the jack pine, although the 7,500 trees per acre left are still far too many for best growth. The benefit, although similar, has been less than that reported by Cox[3] in 1938.

Snow as a Thinning Agent

That snow can be a very important factor in reducing the stocking of dense jack pine stands is also brought out in the study. In April 1947 the area had a rather heavy fall of wet snow. This did no harm in the unthinned stands or to the thinnings made in 1941, but caused considerable damage to the plots thinned in 1946. About 20 percent of the trees left on each of the two spacings were bent or broken beyond recovery and many others less severely injured. Plots thinned by the crop-tree method suffered only minor losses.

In November 1947 the area was hit by another heavy snowstorm, this one accompanied by a strong

[3] Cox, W. T. Snowshoe hare useful in thinning forest stands. Jour. Forestry 36:1167-1168. 1938.

TABLE 3.—RELATION OF HARE GIRDLING TO TREE DIAMETER AND SPACING IN 10 YEAR OLD JACK PINE, 5 YEARS AFTER THINNING

D.b.h. class or group	Unthinned		4 by 4 feet		6 by 6 feet		8 by 8 feet	
	Living trees[1] per acre	Injured trees	Living trees[1] per acre	Injured trees	Living trees[1] per acre	Injured trees	Living trees[1] per acre	Injured trees
Inches	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
½	983	100						
1	7,433	76	542	63	159	61	78	55
2	2,142	10	1,477	12	639	13	352	10
3 and 4	58	0	489	1	396	1	231	1
Total	10,616	64	2,508	21	1,194	15	661	12

[1]Reconstructed stand as of 1944 45 when serious hare damage began; totals are therefore intermediate between those after thinning in 1941 and those for 1946 in Table 1.

TABLE 4.—PROPORTION OF TREES SEVERELY DAMAGED BY HEAVY SNOW AND WIND IN AN 11 YEAR OLD STAND

D.b.h. class	Unthinned[1]	Thinned at age 10			Thinned at age 5			
		4 by 4 feet[2]	6 by 6 feet[2]	Crop tree[3]	4 by 4 feet	6 by 6 feet	8 by 8 feet	All spacings
				Percent				
1	62	61	64		34	69	0	39
2	31	38	32	40	15	15	18	14
3 and 4	10	6	7	10	4	2	2	3
Total	54	50	46	32	13	10	7	16
Basis: No. of trees	654	269	135	42	479	276	345	1,100

[1]Does not include "patch" damage, this estimated to be an additional 10 to 20 percent.
[2]About 20 percent of the severe damage occurred in April 1947.
[3]Crop trees only; no tally made of damage to unthinned noncrop trees.

north wind. From the adjoining road, the stand the next spring appeared to be a complete tangle of down trees (Fig. 3). Accordingly, a survey was made of the unthinned plots, those thinned when 5 years old and those thinned at 10 years to find out if there was any difference in damage between treatments.

This survey disclosed that in the unthinned area 63 percent of all trees were damaged by the snowstorm, most of them severely (Table 4). But this does not tell the whole story, for the damage survey did not sample the numerous patches and strips where all trees were down. Damage to the stands thinned at 10 years of age proved even higher than that in the unthinned plots. This may have been more the result of the short time since thinning than of the age at which thinning was done. In both spacings, three-fourths of the trees were damaged and half of them so badly as to appear beyond recovery. The crop-tree release plot was not hit as hard, although damage to unthinned noncrop trees seemed about as high as on the control areas. The plots thinned when 5 years old, on the other hand, showed relatively little injury[2]. In all treatments and in the unthinned stand, damage definitely decreased with increase in diameter. Very few of the largest trees were hurt.

At first glance it appears that snow damage, which reduced the unthinned stand from 7,500 to 3,600 trees per acre, might be considered beneficial. This reduction, however, is not uniformly distributed nor does it include the loss in patches of completely flattened trees, some of which are ½ acre in size. Furthermore, since wet snow is of fairly frequent occurrence in the northern Lake States, enlargement of existing down patches and development of new ones is quite probable. Mortality resulting from snow damage, because of its haphazard nature, cannot be relied upon to correct serious overstocking in young jack pine stands. On the contrary, it leads to an undesirable stand of patchwise character. Practices which will minimize snow damage, therefore, are highly desirable.

Since losses from hare girdling are also unpredictable, it is apparent that some type of thinning is needed to convert such stands into more productive forest. The optimum spacing cannot be fully decided upon as yet. But it is clear from the evidence presented that thinning in stands like these should be done at an early age, before the trees have become so spindly that they cannot recover from snow bending. If it is delayed much beyond 5 years, the stands run a high risk of serious snow damage.

[2]Had these plots been larger, damage would have been markedly reduced; most of that found was patch damage which originated in surrounding unthinned areas and worked into the thinnings much as dominoes on end go down when pressed by their neighbors.

Reducing Thinning Cost by Mechanical Methods

Obviously, thinnings in jack pine seedling stands must be done cheaply if they are to be practicable. Conventional hand thinning in dense stands requiring an investment of several man-days per acre is costly. Since mechanization has cut costs greatly in other forest operations, it would seem to offer possibilities in reducing the cost of thinning. Trials of two different mechanical methods made in Wisconsin during the past few years indicate such methods to be promising. Although the work is not yet far enough along to draw final conclusions, the methods tried suggest definite possibilities in lowering thinning costs.

Probably the earliest attempt in the Lake States to thin dense stands by mechanical means was made by Frank Fixmer, forester for the Mosinee Paper Mills Company, in cooperation with the Lake States Forest Experiment Station. A 9-year-old natural jack pine stand near Solon Springs, Wis. about 10 feet tall and 1 inch in diameter, ranging from 6,900 to 18,500 stems per acre, was thinned in June 1945 with a heavy Athens disk, 6 feet wide, pulled by

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FIG. 3.—Damage to dense unthinned jack pine by the heavy snow storm of November 7, 1947 (Aurora jack pine seeding, Superior National Forest).

TABLE 5.—RESULTS OF MECHANICAL THINNING WITH AN ATHENS DISK IN 9-YEAR-OLD JACK PINE, NORTHWESTERN WISCONSIN

Block number	Treatment	Proportion of area left undisked		Thrifty trees injured by disking	Final stand per acre
		Expected	Actual		
		Percent	*Percent*	*Percent*	*Number*
1	Alternate 6-foot wide strips left standing	50	56	3	12,456
2	6-foot wide strips cross disked into 6-foot squares	25	28	13	4,580
3	3-foot wide strips left standing with 6-foot disked strips intervening	33	47	9	5,053

a crawler tractor. Thinning was done by disking in parallel strips of different widths and by cross disking into blocks (Table 5). A small-scale trial of hand thinning was also made for comparison. The stand is quite similar to that at Aurora previously described.

Cost of mechanical thinning ranged from $2.70 to $6.00 per acre, compared to $10.20 per acre for 17 man-hours required for the hand operation.

The mechanical thinning resulted in a 44- to 72-percent reduction in stand (Table 5), but, of course, had no effect on the intervening strips or squares. As a result, some supplemental hand thinning will probably be required for optimum spacing, but the cost of such additional work will have been very greatly reduced by the disking. Because of root damage, barking, or sudden opening of the stand, a period of adjustment of 4 to 5 years after disking appears necessary before any appreciable response can be expected from the thinning.

A second trial of mechanical thinning was made in the early summer of 1948 by Messrs. F. G. Kilp and R. C. Dosen of the Nekoosa-Edwards Paper Company, in cooperation with the Lake States Forest Experiment Station. This test involved hand thinning, disking in strips with an Athens disk, and clearcutting in swaths with a 36-inch self-propelled circular power saw.[1]

The stands in which these tests were conducted were 23 to 28 years of age and before thinning had from 2,170 to 6,000 stems of jack pine per acre from 1 to 4 inches d.b.h., with a few trees up to 8 d.b.h.; total height varied from 15 to 30 feet. Some 130 to 400 scrub oaks per acre were also present.

Of the three methods used, swath cutting with the power saw appeared to hold the most promise. This method required only 4.4 man-hours per acre, compared to 17.3 man-hours for hand thinning a similar stand to a 5-foot spacing. Disking was not very successful in this stand.

The technique used in the "saw thinning" was to thin from below, running the saw back and forth in somewhat parallel strips and going through the densest patches of pine, cutting the small, spindly trees and leaving the larger, sturdier, and more snow-resistant ones. Samples showed a stand reduction of jack pine from 2,170 to 1,260 trees, and scrub oak from 130 to 35 trees per acre. Practically all the trees cut were in the undesirable 1- and 2-inch diameter classes. Damage to the residual stand was only 0.2 percent. In contrast, on the disked area 4.3 percent of the trees left were damaged by scarring, bruising, or tipping by the disk.

Thinning with a power saw results in a surprisingly good job but it still tends to leave trees somewhat too dense between the treated strips. The chief disadvantage of a saw of this type (where the operator walks behind the machine grasping it by the handles) is the extreme fatigue caused by the tendency of the machine to whip to and fro when the tires strike the low stumps of the cut trees. It works best on rather smooth, sandy terrain free of surface rocks or boulders and with little or no windfall. On rocky sites extensive damage may occur to the blade. Such saws might have adaptability to a wider range of conditions and provide a further reduction of costs on larger-scale operations if they were equipped with a short crawler-type track, or if the blade were mounted in front of a small tractor so as to be easily adjustable from the driver's seat for height and sidewise motion.

[1] Normally used for cutting pulpwood or chemical wood.

An interesting sidelight on the thinning done on the Nekoosa-Edwards industrial forest was that considerable damage occurred from bark beetles (*Ips pini* and *I. grandicollis*) in thinnings made in mid-summer. The insects apparently moved from the slash created by thinning to standing trees, especially those scarred by the disk or root sprung. No insect damage was noted in plots hand-thinned in April. Apparently slash from such thinning dried out early enough in the season so that it did not make a favorable beetle habitat. This observation leads to the conclusion that thinning in young jack pine in the Lake States can more safely be done from September to April than during the summer.

Another possible alternative for thinning stands where the trees are from $\frac{1}{2}$ to 2 inches d.b.h. would be the use of a sharpened V-shaped or angled cutter bar mounted on a small crawler tractor and set to cut a swath about 4 to 5 feet wide. Similar machines, used for brush cutting and land clearing, are already on the market, but are much too wide for thinning purposes. In Saskatchewan, plans are being made to thin dense young jack pine by an adaptation of a power mower with hand thinning to be used in the intervening unthinned strips.[5]

Summary and Conclusions

The Aurora jack pine seeding, established on the Superior National Forest in 1937, gives striking evidence as to what often happens when overdense jack pine seedling stands are left to nature. Despite heavy mortality from natural suppression and girdling by snowshoe hares, the stand at 10 years of age contained 7,500 trees per acre. These averaged 15 feet in height and 1.5 inches d.b.h. Their spindly form was an important factor contributing to damage from a heavy wet snow in November 1947. Over 50 percent of the trees were broken off or so bent to the ground as to be beyond recovery. In addition an estimated 10 to 20 percent of the stand was completely flattened, leaving holes up to $\frac{1}{4}$ acre in size.

Half-acre thinning plots put in when the stand was 5 years old came through the storm with little damage; only about 10 percent of the trees were severely damaged. On the other hand, thinnings made at 10 years of age (1 year prior to the snow damage) were damaged even more severely than the unthinned stand. Thus it is obvious that to minimize the chances of serious losses from snow damage, dense jack pine seedlings should be thinned at a very early age. This means while the trees have small enough crowns that if bent over by snow they can spring back upright and can soon develop stiffness to resist such injury. The proper age for such thinning would seem to be about 5 years, or possibly in some cases even younger; 10 years appears to be rather late in stands of this kind.

In addition to reducing damage from snow, the early thinnings have been of decided benefit in concentrating growth on fewer trees. As a result, commercial cutting will be possible here much earlier than in the untreated stand. Although the best cannot be definitely prescribed as yet, the 4 by 4-foot spacing to date seems superior to the heavier thinnings. The trees are not only taller and almost as large in diameter as those in the wider spacings, but are also of better form. Moreover, the much larger number of trees will allow a choice to be made in future thinnings and furnishes a reserve for mortality.

These thinnings were made by hand at a cost of 4.2 to 6 man-days per acre. Such an expenditure, however, even in times of low labor cost is rather high to make as an investment in stands of as low stumpage value as jack pine. The cost of thinning can be reduced about half by crop-tree release or head-tree thinning, but no data are available on how stands so thinned at about 5 years of age stand up under heavy snow. Possibly in view of the dense stand they carry, crop-tree thinnings would be damaged as badly as unthinned jack pine.

Mechanical disking, leaving one-fourth to one-half of the stand in strips or in a gridiron pattern, and cutting in parallel strips with a self-propelled saw have been used to thin dense young jack pine in Wisconsin. Both methods are much cheaper than hand thinning, but like other possible strip-wise thinning methods (for example those using power mowers or brush cutters) require some form of hand thinning in the overdense intervening strips. For the latter areas crop-tree thinning might prove sufficient. This could be done by hand methods or possibly by means of poisoning the unwanted trees with ammate, 2, 4-D, or other herbicides.

[5] Information obtained in personal conversation with E. J. Marshall, director of forestry, Province of Saskatchewan.

Forestry on the Larger Holdings in the Northeast[1]

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Chief forester, Hollingsworth and Whitney, Co., Waterville, Maine.

WHAT IS MEANT by "Larger Holdings in the Northeast?" There are no large areas of timberland in any single ownership in Rhode Island, Connecticut, or Massachusetts. There are none in the pine or hardwood regions of Maine, New Hampshire, or Vermont, except in the two national forests in New Hampshire and Vermont. This paper refers only to privately owned lands. Hardwood and pine manufacturers generally depend on purchased stumpage or on the purchase of logs delivered to their plants. Therefore, all lands outside the spruce and fir region of Maine, New Hampshire, and Vermont can be eliminated from this discussion.

Who are the owners of large holdings in the spruce and fir region? In general there are two classes: (1) the pulp and paper companies and (2) families, individuals, or investment owners. Most of the large holdings are in Maine. The U. S. Forest Service reappraisal in 1946 showed the acreage of timberland in large private holdings as follows:

Maine	8,618,102
New Hampshire	184,659
Vermont	278,254
Total	9,281,035

A "large holding" is defined as one of 50,000 acres or more. According to this, 92 percent of this land is in Maine. Most of it is controlled by about 30 owners.

Ownership has gradually passed from the families, individuals, and investment owners to the pulp and paper companies. This process is continuing. Investment ownership is usually administered by some consulting forestry firm or by a local manager. As time goes on the actual ownership is divided among more and more people. The death of the original purchaser invariably splits the ownership among a number of heirs. Inheritance taxes may force the sale of part of the land at such times. In any group of owners there are always some who want to get their money out of the property. All of this promotes the sale of land, and for the past fifty years pulp and paper manufacturers have usually been the buyers. Some of the old pulp and paper companies that have operated in Maine but owned no timberlands are now either buying land or giving serious consideration to buying. Other companies with a long established policy of land ownership have been increasing their holdings.

History

Maine has a total forested area of over 16 million acres. This area was the first in the United States to be cut heavily for lumber to supply national and international markets. The cut was for white pine sawlogs and only the best were taken. In many stands the result was a type of selection cutting which would meet with any silviculturist's approval. The operators started along the coast and gradually worked their way inland along the major river valleys. As pine became scarcer and inaccessible, it was profitable to turn back to the coastal areas and to cut over lands previously logged. Much of southwestern Maine and appreciable areas along the coast are natural pine lands where one crop of white pine follows another if reasonable care is taken. This pine area has long been settled, towns have been organized and much is farmed. Taxes are comparatively high since the timberlands in many cases must bear much of the cost of supporting schools, highways, and other town improvements. Farther inland pine is displaced by spruce and fir, towns are not organized and there are less improvements to be supported. So taxes are lower.

Maine timberlands can, therefore, be divided along more or less natural lines into two groups. One of these is the area of 10,262,000 acres in the Maine Forestry District and the other is the some 6,000,000 acres in organized towns.

The timberlands in organized towns include practically all the pine lands as well as part of the spruce-fir region. Taxes are high, but the lands are accessible and intensive forestry practice is usually practicable. The lands have generally been cut over many times. It does not follow that this has always resulted in greater timber production from the area. Too often it has led to fires or cutting of such intensity that the advantage of accessibility has been lost, although the taxes continued to be high because of accessibility and the fact that organized town improvements must be paid for, at least in part, by taxes on timberlands.

Maine's present production of lumber is largely from the coastal area, where forest fire protection has been comparatively poor. From 1891 to 1948 organized towns or municipalities were responsible for their own protection. It was not until 1949, stimulated by the extensive fires of October 1947, that the legislature enacted laws that brought this 6,000,000 acres of land under the protection of the state forest fire suppression organization. The state has had excellent protection over the remainder of its forests since 1911 and now it is reasonable to believe that protection of the lands in organized towns will compare favorably with that in any other section of the country.

Maine's greatest forestry problems are concentrated in this settled coastal section where higher taxes intensify the problem. A state law discourages tax delinquency, since such taxes can be collected on other property of the same owner, and to that extent favors good cutting practices. Poor cutting practices and resultant loss of income from the land is immediately felt by the landowner

[1] Presented at a meeting of the New England Section, Society of American Foresters, Boston, Mass., Feb. 23, 1950.

because of high taxes. On many areas, anything other than maximum production of timber through the practice of intensive forestry makes the rate of taxation almost confiscatory. H. H. Chapman has well said, "Only two courses are open to forest owners under these conditions—either keep the land productive or, if this is not possible, find a victim who will take title to it."

The 10,262,000 acres of land in the Forestry District is almost entirely the property of owners of the so-called "large holdings." This district is a state organization formed in 1909 with inspiration and backing from timberland owners. It is unique in that respect. The primary objective at the time of organization was to provide fire protection through a self-imposed mil tax. Forest fire protection since that time has been very good. Taxes are low since the greater part of the expenditures are for fire protection. There are few roads or other improvements. Much of the timber is very inaccessible and some of the area has never been cut over. The only method of transporting logs or pulpwood has in many cases been by water. Pine sawlogs were driven to tidewater mills until the operable quantities of pine were gone and the pulp and paper mills went after the spruce. Spruce was driven first as long logs and later as 4-foot wood. Until recent years balsam fir was considered a weed tree and could not be marketed. The logging of these inaccessible areas required considerable expense in building camps and dams and in improving streams. The areas could not and cannot now be handled other than by the practice of extensive forestry. As mechanical equipment has come into common use it has become practical to build more roads and to haul long distances by truck and rail and this has extended the area on which intensive forestry practice can be applied. Most paper companies are now using large quantities of fir and this has made it possible to operate areas that had formerly been considered practically valueless. This is true of both the accessible and the inaccessible timberlands.

The history of logging for white pine, then for spruce, and a conversion to stands that have large proportions of fir also applies to the spruce and fir region in New Hampshire and Vermont. The region will never again produce such crops of pine or spruce as were in the original stands. Industry is faced with the necessity of using the fir that is so abundantly reproduced after any method of cutting. For those who must have spruce, it is possible only to increase its proportions in spruce-fir stands by controlling cutting methods. For those who can use fir the outlook is encouraging, since this species grows rapidly and undoubtedly can develop much greater volume than could the pine and spruce of the original stands.

It is not only interesting but important that we look at what the U. S. Forest Service has to say about cutting practices on large holdings in the Northeast. In its reappraisal of 1946 it states, in regard to cutting on the large holdings in the country *as a whole*, "The fact that 29 percent of the cutting on large holdings rates good to high-order is worthy of special mention. Only 32 percent of the cutting on these properties is poor to destructive. The large holdings, however, include only 51 of the 345 million acres in private ownership. Pulp company lands get better treatment than those of lumber companies." That is the summary on a national basis but the New England story is even more encouraging. While in the country as a whole only about 15 percent of the forested land is reported to be in large holdings, 33 percent of the total in New England is in that class. The Forest Service indicates that 95 percent of the cutting on these properties is fair to high-order and only 5 percent is poor, while none of it is destructive. This is caused largely by natural reproduction of such species as spruce, fir, pine, sugar maple, yellow birch, white birch, aspen, and beech. Even after a fire the lands reproduce to white birch and aspen. The silvicultural problem in New England is not so much to insure reproduction as to regulate the race between the many desirable species that reproduce naturally.

Another interesting fact stated in the reappraisal report is the percentage of forest land under various degrees of management. The report indicates that 97.4 percent of New England forest land owned by pulp companies is under extensive management. This is exactly the same percentage as on the national forests of New England. However, the two national forests did have in 1946 an additional 1.7 percent under intensive management while the pulp companies had none.

Increased Interest in Conservation

There has been considerable increase in interest in the practice of forestry on the large holdings in the Northeast during the past few years. There are a number of reasons for this:

1.—Wartime shortages emphasized the problem. As in practically every line of endeavor, the timber contribution that was required by our wartime effort was such that the question of supply became important.

2.—In 1948 approximately one-third of the pulpwood required for manufacture in Maine was imported from Canada.

3.—New England mills have reached out farther and farther along roads and railroads for their timber. Cutting of the forests along these routes has been intensified.

4.—The fact that we now have more highways, together with the use of trucks and tractors in the woods, demonstrates that intensive forestry can now be applied to new areas. Bulldozers for road construction and trucks for hauling have opened new areas.

5.—The death of most of the yellow birch and paper birch in Maine because of die-back and the bronze birch borer epidemic has forced hardwood manufacturers to

go greater distances for their stumpage. The threat of a spruce budworm epidemic has received serious consideration by all timberland owners.

6.—Competition from southern mills and from hardwood pulpwood users has intensified the forestry problem.

Factors Opposing Conservation

Showing or preventing the practice of better forestry methods are:

1.—Taxes. This problem has already been discussed.

2.—The threat of fires. Although forest fires have not been a serious element in the forestry problem in the Maine Forestry District since it was established, they have been a big problem in the pine saw-timber area. No owner can risk much money in timberland management unless he has reasonable assurance of safety from fire.

3.—The threat of loss from disease or insect attack has the same effect as the danger of fires.

4.—Absentee owners of inaccessible lands often want the maximum income from their lands when any is available. They are inclined to see only the immediate income and to overlook long-term values.

5.—Competition forces industry to operate at the cost level and with the policies of the most efficient producer. On one hand we have anti-trust laws that prohibit cooperative agreements between members of industry, and on the other we have the desire for conservation and for an adequate future timber supply.

6.—Seasonal work and low quality woods labor make it difficult to improve forestry practices. Competition for labor enables the chopper to control cutting methods. He cuts as he chooses. This is more likely to be true on large operations than on small ones since here again all are forced to follow the lead of the most efficient producer. The recent change in the wage and hour law has temporarily intensified this problem.

What is Being Done?

1.—All owners of large holdings are interested in improving the quality of forestry practices. It is extremely difficult for any one, or any small group, to act alone. Competition tends to prevent this, as has already been mentioned. Manufacturers are well aware of the need for conservative cutting of farm woodlands. Several of them have offered their assistance to small woodlot owners to do the same job that is being done by the county forester or farm forester.

2.—Timberland owners have done much to encourage the establishment, by state and federal governments, of farm foresters in New England. They believe that the educational approach to the problem of more timber production is a good one. Most of them agree that it is best handled by government. Most of these foresters have gone on the job since the war and the results have been good. Maine has only two of them. Other New England states have much more complete coverage. New Hampshire has one in each county, except that one of the men handles two counties.

3.—New laws have recently been enacted in Maine and New Hampshire that effect the large holdings. New Hampshire's new tax law is being watched with interest by all states in the Northeast. This is a yield tax with provisions for encouraging good forestry practices. It is the purpose of this law to "give an incentive to the owners of standing timber to abandon destructive cutting practices in favor of long range forest management plans and to promote the restocking of depleted forest lands by conserving an understory of immature trees of desirable species. It is further designed to provide a continuous, sustained yield of wood and timber for New Hampshire's wood using industries." Maine has extended state forest fire protection throughout the entire state and established a permanent organization in areas where one did not previously exist. The legislature also passed an act authorizing cooperation with the other New England States and with provinces of Canada in the promotion of effective prevention and control of forest fires. This would provide for region-wide plans and would authorize cooperation which has in the past been handled on an emergency basis and has usually been too late to be effective.

A bill to regulate cutting was introduced in the last session of the Vermont legislature. It did not pass, but indicates the trend.

4.—Forestry forums are being held monthly during the winter season in two sections of Maine and in northern New Hampshire. Foresters, operators, and landowners are getting together to discuss their problems and to exchange ideas.

5.—Many of the purchases by investment owners in recent years have been made through consulting foresters and these lands are managed by consultants. Other investment or family ownerships are similarly managed. In general, these lands are well-managed. Possibly they are appreciably better managed now than at the time of the 1946 Forest Service reappraisal. In some instances managers of these lands have set their cutting practice standards so high that they have had difficulty in selling stumpage to pulp companies.

One move that has taken place since 1946 which raises the average quality of cutting practices on this type of ownership was made by Dead River Co. of Bangor. This company entered into an agreement with the Eastern Corporation, paper manufacturers, that places some 90,000 acres of its lands under intensive management. Integrated logging for the most valuable product available is to be practiced and the growing stock built up by cutting not more than three-quarters of the growth. Truck roads are to be built and maintained. Diameter limits have been established for general control of the cutting of all species.

Better markets for hardwoods in recent years have enabled managers of these lands to improve their cutting practices appreciably.

6.—Most of the owners of large holdings in New England support American Forest Products Industries, Inc. This is a cooperative

organization through which the industries work to promote education that will improve forest cutting practices and assist in the prevention and control of forest fires. Its Keep Green program is operating in Maine and should do a lot to prevent forest fires. It has received the wholehearted support of all elements of the industry, newspapers, radio, the Maine Forest Service, and business in general. The Tree Farm movement has been started in Massachusetts. This is a move to encourage woodland owners to follow practices which will benefit them by greater sales of forest products and also maintain a future supply of these products. "Trees for New Hampshire" and "Trees for Vermont" programs are operating in those states. New Hampshire started its program in 1948 and Vermont started last October. These programs, fostered by AFPI, are designed to step up production from woodlands through educating owners and operators in the use of better cutting practices. In these two New England states they have been closely linked with the farm forestry program. All these AFPI programs are designed to strengthen the hand of existing state forestry organizations.

7.—The New England Forestry Foundation is another relatively young organization working on the problem of stepping up woodland production. It is now operating in Massachusetts, New Hampshire, and in the pine region of Maine. It is a nonprofit corporation intended to give complete forestry service to woodland owners at cost. This involves the estimating of timber, silvicultural work, planning of cuts operating the timber, and marketing.

8.—Several pulp companies in Maine are buying some 3,500 acres of forest land near Bangor on which the U. S. Forest Service is to establish and maintain an experimental forest. The work will be primarily on methods of handling spruce and fir for the production of pulpwood.

9.—Several pulp companies are working with the U. S. Forest Service, and with some assistance from the University of Maine, on a cooperative study of growth of all tree species and types of stands in northern and eastern Maine and northern New Hampshire. By exchanging information and standardizing the methods of doing the field work it is hoped that duplication can be avoided.

10.—Hardwood industries in Maine have been hit hard by the loss of much of the birch on which most of the plants depend. Three years ago the state appropriated a sum up to $10,000 for each of two years for the study of the cause and to determine remedies for this difficulty. The money was to be available only as it was matched by an equal amount from the industry and industry has, to date, produced some $16,000 or $17,000. Experiments in spraying DDT by various methods and of direct seeding and planting of birch have been conducted. The spraying has been very successful in preventing further mortality of the birch. It costs less than $1.50 per acre on a large area for airplane spraying. One company plans to spray the hardwood stands on more than 20,000 acres this year.[2] Others are considering similar work.

11.—Maine is threatened with another spruce budworm epidemic such as the one that occurred between 1910 and 1920 and which is estimated to have destroyed over 20 million cords of spruce and fir. Fairly extensive outbreaks have already appeared in northern Aroostook County and near Jackman in Somerset County. An experimental spraying of 20,000 acres of spruce and fir in Aroostook County to combat this is planned for next June.[3] It is to be financed by $15,000 of federal money, $7,500 from the state and $7,500 from the landowners in the Forestry District. Sixteen experimental plots will also be sprayed.

To summarize, forestry practice is dependent on general business conditions. Disorganized and shifting markets prevent the long time planning essential to planned growth of timber. The economical production of timber requires production with thought for the future, as well as for the immediate cost.

Competition forces all industry to try to equal the cost of the cheapest producer and this leads to such things as the buying of any timber that an owner chooses to sell regardless of species or size.

Use of balsam fir and recognition of the fact that many of the spruce-fir stands are actually old-growth fir stands instead of young spruce stands would lead to better utilization and the production of more timber. Cutting of fir on a short cutting cycle is one method of preventing the loss of large volumes of this species.

New Hampshire's new method of taxing timberlands will be watched with interest by all the New England states and timberland owners.

Forest fire suppression is comparatively efficient on the large holdings and educational forest fire prevention work is being stepped up. However, it does appear that for every hour of Class 4 or Class 5 weather extensive areas of timber are sure to burn. Rain is still the best suppressor of fires and is depended upon to a large degree. It has been the good fortune of the large holdings of timberlands in New England to be within an area where, in past years, rain has fallen at relatively short intervals.

It is very possible that the volume of timber now standing on the large holdings of the Northeast is greater than at the turn of the century but the quality is lower.

This paper is just a summary of the forestry situation on the large holdings. Complete coverage would require papers of equal length on each of the many subjects covered here with a paragraph. Solutions for many of the old problems are known and are being put into effect. For the most part these solutions won widespread approval

[2] This spraying was not done because the stand is apparently suffering no accelerated losses.—Editor's note.

[3] Parasitism and winter kill resulted in a failure of the epidemic to develop as expected in the summer of 1950. Consequently, the spraying was not done.—Editor's note.

years ago. Research to produce new knowledge is less needed than are the favorable business conditions that will allow the use of knowledge we now have. However, research is also essential and fields have been mentioned in which it is being carried on cooperatively by industry and government.

The Use of Herbicides for the Control of Alder Brush and Other Swamp Shrubs in the Lake States[1]

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LARGE AREAS of formerly productive coniferous swamps in the Lake States are now occupied by speckled alder (tagalder), willows, and other worthless hog shrubs as a result of logging, fires, and the larch sawfly epidemic. The alder (*Alnus incana*), where dense, casts a heavy shade which prevents or retards successful regeneration of valuable tree species. From a study of type maps on sample areas, it is estimated that alder is of sufficient acreage and density to constitute a silvicultural problem in about 10 percent of all swamp and swamp-margin forest types in northern Wisconsin alone. This may amount to about 2 percent of the forest land in this area, or over 200,000 acres, of which probably half is of fairly good potential productivity. In the Lake States as a whole the area involved would no doubt be two or three times as great.

Some of these areas will gradually restock naturally, but others will not do so in any reasonable length of time. Consequently there has been an interest on the part of forest managers in economical techniques for restoring such areas to timber production. The problems involved include drainage, regulation of the deer and rabbit populations, and planting, but the first question is what to do about the alder.

In the past few years a number of new chemicals have been developed that are finding wide application as herbicides. The possibilities of using some of these products for the control of alder are reported in this article.

Review of Literature

Of the rapidly growing literature on uses of herbicides for the control of woody plants, the majority deals with the application of these chemicals to upland shrubs and trees. To date, there has been relatively little investigation of the control of swamp shrubs by the new herbicides. Between 1945 and 1947, Day (4) tested a variety of chemicals in upper Michigan. He reports alder, hazel, and willow as generally hypersensitive or sensitive to foliage sprays of 2, 4-D and ammonium sulfamate, applied in the middle of the growing season. Considerable variation was noted in the effectiveness of the several formulations of 2, 4-D used. Alternate dogwood, mountain maple, and red maple were reported as generally tolerant to these chemicals. The 2, 4-D formulations used varied from 1,000 to 4,500 parts per million applied with water, kerosene, or fuel oil. Several esters and salts of the parent acid were used.

Zehngraff and von Bargen (7), after testing herbicides in Minnesota during 1947 and 1948, reported nearly complete elimination of old stems of hazel (*Corylus* sp.) using 2, 4-D at the rate of 2.5 pounds per acre, and Ammate (ammonium sulfamate) at 50 pounds per acre. However, Ammate severely injured or killed considerable numbers of pine seedlings beneath the brush and also failed to eliminate resprouting of the hazel unless applied in very high concentrations (200 pounds per acre). In contrast, 2, 4-D greatly reduced sprouting of hazel and did not injure pine seedlings to any extent. Zehngraff and von Bargen rank several woody genera in order of their susceptibility to 2, 4-D as follows: *Corylus, Salix, Amelanchier, Populus, Alnus, Rosa, Rubus, Quercus.*

Peevy (4) recommends Ammate for control of low-value upland hardwoods in the South. Ammate crystals placed in axe cuts or "girdles" at the base of the tree are reported to kill the tree and eliminate sprouting. Another satisfactory method is to apply a water solution of Ammate (4 pounds Ammate per gallon of water) in "frills" cut around the base of the tree. Species vary in their reactions, but several inferior oaks, willows, elms, ash, etc., can thus be eliminated.

Maisenhelder (3) reports that sodium arsenite and ammonium sulfamate (Ammate) gave good control of certain southern bottomland hardwoods. He points out that sodium arsenite is the most effective poison yet discovered for these species, but is hazardous to domestic animals, wildlife, and man. Ammate is harmless to man and animals. Arsenite is effective when applied in frills. Ammate solution when applied with a swab on stumps or as a foliage spray

[1] Credit is due Nelson L. Stanton and E. E. Stahl of the U. S. Forest Service for aid in installation of the experiments

Elder, Elwell, and Ronsho (2) have tested several chemicals for brush control in Oklahoma and have compiled a list of woody plants showing degree of control with 2, 4-D. They rate willow (*Salix nigra*) as susceptible to 75 or 80 percent control and American elm to only "slight control." They consider 2, 4, 5-T, or combinations of 2, 4, 5-T and 2, 4-D, to be superior to 2, 4-D used alone. Ammate gave good control of all woody plants common to the test areas, but repeat sprayings were necessary to kill some species that resprouted.

A review of the literature brings out the fact that careful testing is necessary to determine the reaction of each problem species to specific herbicides under well-defined conditions and methods of treatment.

Plan of the Experiment and Costs of Treatment

To test the various chemicals and treatments, a series of 46 twentieth-acre plots (66 by 33 feet) were laid out in an alder swamp near Hiles, (Forest County) Wis. There were four replication blocks of eleven plots each, plus one additional treatment of two plots. An untreated isolation strip of 16.5 feet was left between plots.

The alder was 8 to 12 feet high and very dense, with 6,000 to 11,000 larger stems per acre and usually 4,000 to 6,000 2- to 3-foot sprouts per acre. In addition, there were some redosier dogwood (*Cornus stolonifera*) and other minor species.

In the area there was a thin stand of about 278 trees per acre from 1 to 8 inches d.b.h. of northern white-cedar (*Thuja occidentalis*), black ash (*Fraxinus nigra*), balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), tamarack (*Larix laricina*), yellow birch (*Betula lutea*), white pine (*Pinus strobus*), hemlock (*Tsuga canadensis*), and red maple (*Acer rubrum*). There were also about 288 trees per acre between 1 and 8 feet high, mostly black ash and balsam fir.

The four general methods of treatment and four different chemicals used and their costs were recorded (Table 1). Several types of 2, 4-D products and Ammate were used as foliage sprays on old-growth alder (Treatments 2, 3, 4, and 5) as well as on 2-month-old alder sprouts (Treatments 6 and 7) which originated after cutting in May 1947. Also tested was the cutting of large alder and daubing the freshly cut stumps with Ammate (Treatments 8 and 9). Cutting was done in May and in August, without subsequent chemical treatment (Treatments 10 and 11). All treatments were carried out in 1947 except numbers 5 and 9, which were made in 1948.

Foliage was sprayed with a standard hand-operated Indian back-pack fire pump of 5-gallon capacity. Ammate was swabbed on freshly cut stumps with a cloth

TABLE 1.—COSTS OF HERBICIDE TREATMENTS

Type of treatment	Treatment No.	Chemicals, concentration, and date of treatment[1]	Man-hours required per acre: Cutting	Spraying	Total	Cost per acre:[2] Cutting	Spraying	Chemicals	Total
			Hours			*Dollars*			
Check	1	No treatment							
	2	Weedone[3] 1 qt. to 25 gal. water (5000 p.p.m.) August 1947		2.08	2.08		2.08	4.90	6.98
	3	Esteron 44[4] 3 pints to 50 gal. water (5000 p.p.m.) August 1947		2.08	2.08		2.08	3.70	5.78
Foliage spray on old alder	4	Ammate[5] 4 lbs. per gal. water, August 1947		6.92	6.92		6.92	13.00	20.92
	5	Esteron 245[6] 1 to 200 or 98 gal. solution per acre (2450 p.p.m.) July 1948		3.46	3.46		3.46	9.22	12.68
	6	Esteron 44 2 pints in 50 gal. water (2500 p.p.m.) Brush cut in May, sprouts sprayed in August 1947	23.20	1.00	24.80	20.30	1.90	2.80	27.00
Cut brush, spray foliage of resulting sprouts later	7	Ammate 4 lbs. per gal. water. Brush cut in May, sprouts sprayed in August 1947	16.00	1.41	17.41	16.00	1.41	14.40	31.81
Cut brush, and daub chemicals on stumps	8	Ammate 4 lbs. per gal. water. Brush cut 1-31/2 high and daubed in August 1947	18.50	4.80	22.30	18.50	4.80	4.80	27.30
	9	Ammate 2 lbs. per gal. water. Brush cut 2-31/2 high and daubed in July 1948	10.70	10.70	21.40	13.70	10.70	3.41	24.81
Cut old alder only	10	Cut in May 1947	23.00		23.00	23.00			23.00
	11	Cut in August 1947	24.80		24.80	24.80			24.80

[1] "Weedone" contains the ester(s) ester of 2, 4-dichlorophenoxyacetic acid (2,4-D) (40 percent). [2] "Esteron 44" contains the isopropyl ester of 2, 4-dichlorophenoxyacetic acid (44 percent). [3] "Esteron 245" contains the butoxy ester of 2, 4, 5-trichlorophenoxyacetic acid (4.45 percent).

[4] "Ammate" is 85 percent ammonium sulfamate (sold in crystalline form). It is corrosive to metal and somewhat irritating to the skin.

[5] Labor costs based on a wage scale of $1.00 per hour. Costs of chemicals were as follows: Weedone—$10.80 per gallon; Esteron 44—$13.00 per gallon; Ammate—8.16 per pound; Esteron 245—$19.00 per gallon.

wrapped around the end of a stick. Cutting was done with a "Phelps release tool," a light brush knife developed on the Nicolet National Forest.

Dates of the various operations in 1947 were as follows: cutting May 21 to 23 or August 5 and 6; spraying August 5 and 6. In 1948 the date of all operations was July 16.

Costs per acre ranged from $5.78 to $39.92 (Table 1). The most costly treatment (Ammate used as a foliage[4] spray) could have been done much more cheaply by using a weaker concentration of the chemical. Considering all treatments, Esteron 44 (Treatment 3) at 3 pints in 50 gallons of water was the cheapest.

In the past two or three years there have been substantial price reductions on 2, 4-D and 2, 4, 5-T products. Current (1950) costs of alder eradication with such chemicals would, therefore, be lower than reported in this study (Table 1), since chemical costs in the table are based on prices prevailing at the time the tests were conducted. Various formulations of 2, 4-D esters now sell at about $4 per gallon (in 50-gallon drums), as compared with costs of $11 to $13 per gallon when the tests were made. The cost of 2, 4, 5-T has been reduced from $19 per gallon to about $12 per gallon (in 50-gallon drums). There has been no important change in the price of ammonium sulfamate (Ammate). As sales volumes increase, there may be still further decreases in the cost of herbicides.

Mixtures of 2, 4-D and 2, 4, 5-T are now being marketed as "brush killers" by several manufacturers. These new formulations cost from $6 to $10 per gallon in large drums. The writers have not tested such "brush killers" but results on many woody species are reported to be good. The price of 2, 4-D and 2, 4, 5-T products varies somewhat between manufacturers because of differences in formulation, percentage of acid equivalent contained, and other factors. Such differences should be borne in mind when comparing the cost per gallon of the various manufacturers products.

Results and Conclusions

Comparative results of the various treatments (Table 2) indicate that the single most effective treatment was to cut the alder and daub Ammate on the stumps at the rate of 2 pounds per gallon of water (Treatment 9). Here, the number of stems was reduced from 19,250 to 120 per acre, or 99 percent, in a period of 1½ years after treatment. A similar treatment (No. 8) made in August 1947 was much less effective in reducing sprouting. This was probably due to failure to treat some of the low stumps which were covered by the slash left by cutting the alder. Even in the second-year count made on June 29-30, 1948, there was already a 2-percent greater stand of sprouts than was present before treatment in the spring of 1947. In the later cutting (Treatment 9), stumps were cut much higher and all of the stumps received treatment.

The next most effective treatment was Esteron 245 as a foliage spray (Treatment 5). It reduced the number of stems by 95 percent at the end of 1½ years after treatment. The most effective treatment in 1947 was Esteron 44 used as a foliage spray on 2-month-old sprout growth (Treatment 6), which reduced the number of stems by 90 precent. It was followed closely by Ammate similarly used on sprouts (Treatment 7), which reduced the stand of alder by 86 percent. Spraying old alder foliage with Ammate (Treatment 4) was practically as good.

Foliage sprays of 2, 4-D esters (Treatments 2 and 3) were quite effective in killing old alder, resulting in reduction of 66 and 88 percent respectively, but the number of small sprout alder (mostly 1 to 4 feet tall) had actually increased by 91 and 7 percent respectively.

Cutting of alder without subsequent chemical treatment did not eliminate the brush from the site. Instead, there was a 161- to 165-percent increase in number of sprouts by cutting of the large overstory alder. Based on the June 29-30, 1948 count of alder in treatments 10 and 11, the August 1947 cutting was somewhat more effective than the May 1947 cutting, the total number of stems having been decreased by 25 percent in the former and increased by 34 percent in the latter. Average heights were 1.5 and 3.0 feet respectively. Apparently many more sprouts came up in the third season following treatment.

There are several criteria by which effectiveness of the various methods can be judged, depending on the purpose of the treatment. For instance, rather complete elimination of the alder is necessary along roadsides or under telephone lines. On the other hand, if the purpose of the spraying is to eliminate only a portion of the alder to reduce shade cast on young natural or planted trees below it, then merely a heavy reduction of the overstory alder may be quite satisfactory.

An attempt has been made to rate effectiveness of the various treatments (Table 2). In using the term "effectiveness," consideration is given to elimination of the overstory in case of roadside spraying, relative permanence of treatment, and cost of respraying or retreatment to kill most of the remaining sprouts.

In rating the effectiveness in releasing trees in the understory, the primary consideration is whether the canopy had been opened up enough to provide 50 to 75 percent of full sunlight for the benefit of the seedlings. Excessive opening of the overstory or complete elimination of sprouts is not necessary. In fact, too heavy a kill may cause invasion of sod and grass, a silviculturally undesirable condition because of excessive competition. For example, in plots where a partial kill of the alder overstory was attained, resulting in a 50-percent light intensity at the ground, there were 10 times as many natural first-year seedlings of white cedar, balsam fir, and spruce as in the areas where all the alder overstory was removed.

Considering all treatments, their

TABLE 2.—RESULTS OF HERBICIDE TREATMENTS

Type of treatment	Treatment No.	Chemicals, concentration, and date of treatment	Stems per acre before treatment May 21, 1947 [1]			Stems per acre 3 seasons after treatment [2]			Increase or decrease in stems per acre			Average height 3 seasons after treatment [2]		Relative effectiveness	
			Old alder	Sprout alder	Total	Old alder	Sprout alder	Total	Old alder	Sprout alder	Total	Old alder	Sprout alder	Roadside	Release of trees
									Percent			*Feet*			
Check	1	No treatment	9,620	5,180	14,800	3,180	6,060	13,240	−25	+17	−11	11.7	2.7	Poor	Poor
Foliage spray on old alder	2	Weedone—1 Qt. to 25 gal. water, August 1947. (980 p.p.m.)	8,320	3,620	11,940	2,810	6,930	9,740	−86	+91	−18	11.0	2.7	Poor	Fair
	3	Esteron 44—3 pints to 50 gal. water, August 1947 (3380 p.p.m.)	7,240	5,250	12,490	870	5,620	6,490	−88	+7	−48	8.6	2.7	Good	Good
	4	Ammate—4 lbs. per gal. water, August 1947	11,000	4,060	15,060	1,130	1,560	2,690	−90	−62	−82	18.5	2.3	Good	Good
	5	Esteron 245—1 to 200 or 98 gal. solution per acre. (2150 p.p.m.) July 1948	8,940	6,550	15,490	60	690	750	−99	−89	−95	15.0	1.7	Very good	Very good
Cut brush spray foliage of resulting sprouts later	6	Esteron 44—3 pints in 50 gal. water (3380 p.p.m.) Brush cut in May, sprouts sprayed in August 1947	8,370	5,060	13,430	380	1,080	1,380	−95	−80	−90	10.0	3.1	Good	Good
	7	Ammate—4 lbs. per gal. water. Brush cut in May, sprouts sprayed in August 1947	9,810	5,070	14,880	0	2,060	2,060	−100	−59	−86	—	3.8	Good	Good
Cut brush and daub chemicals on stumps	8	Ammate—4 lbs. per gal. water. Brush cut 1 ft. high and daubed in August 1947	6,130	5,250	11,380	0	6,490	6,490	−100	+24	−43	—	1.9	Fair	Fair
	9	Ammate—2 lbs. per gal. water. Brush cut 3 ft. high and daubed July 1948	11,000	8,250	19,250	0	120	120	−100	−99	−99		.6	Very good	Very good
Cut old alder only	10	Cut in May 1947	6,180	4,060	10,240	120	10,750	10,870	−98	+165	+6	7.5	3.0	Poor	Poor
	11	Cut in August 1947	9,680	5,180	14,860	380	13,540	13,920	−96	+161	−6	3.5	2.6	Poor	Poor

[1] Treatments 5 and 9 made 1 year later—original counts made July 16, 1948.

[2] Treatments 5 and 9 made 1 year later than the others—results are for second season. "Old alder" refers to larger stems usually 6 to 12 feet tall. "Sprout alder" refers to small alder 1 to 6 feet tall originating near or on base of large overstory alder, or as sprouts subsequent to cutting. Final count made January 1950.

effectiveness and cost, and minimum danger to desirable tree species, spraying foliage with Esteron 44 or Esteron 245 appears to hold considerable promise for release of desirable tree species. Weedone was fairly effective. Such treatments cost from $5.78 to $12.68 per acre. By using power sprayers, the costs per acre shown could probably be reduced to $4 to $5 per acre, if the cheaper chemicals such as Weedone or Esteron 44 were used. Crawler tractors with special treads for swamp work (such as used in cranberry marshes) and equipped with power sprayers could probably be adapted for large-scale alder control operations. Aerial spraying also has possibilities on large tracts of brush. However, spray from aircraft may not be distributed uniformly on sites well scattered large trees growing with the brush because of interception by the trees and the relatively high altitude at which planes must travel in safe areas.

Where quite complete elimination of the alder is needed, with a minimum of fellow up, the stumps (height of 12 to 18 inches) with an Ammate solution of 2 pounds per gallon appears very effective. This treatment costs $24.81 per acre. A second treatment of almost equal effectiveness is Esteron 245 as a foliage spray applied at a cost of $12.68 per acre. On larger specimens, the costs of these two treatments could probably be reduced 50 to 60 and 20 percent respectively, assuming power spraying is used for the application of Esteron 245. Roadsides can be sprayed effectively from moving vehicles with hand or power-operated sprayers. Brush can be eradicated along telephone lines by spraying the chemical from a Panamint rotary fire pump operated from the body of the truck driven along the roadside at about 4 miles per hour. This procedure gives good coverage of the brush on a strip about 20 feet wide along the road.

The only adverse effect of treatments noted on the valuable tree species on the plots occurred where

Ammate was deliberately sprayed on the foliage of the trees. This caused browning of foliage on about 5 to 10 percent of the trees. Mortality was negligible. In the usual type of spraying there is a great deal of interception of the spray by the dense canopy of overstory alder and very little of the spray reaches the trees in the understory.

The resistance to browning of foliage by spraying with Esteron 245 was rated for several species. The resistance of balsam fir, black spruce, tamarack, and black ash was "high." That of white-cedar was "medium." No mortality was noted in any of the trees.

Summary

A partial elimination of alder, satisfactory for stimulation of growth of young understory natural or planted spruce of balsam fir, was obtained by treatments with esters of 2, 4-D applied as foliage sprays. These treatments cost from $5.78 to $6.98 per acre.

Nearly complete elimination of alder can be obtained with an Ammate solution swabbed on freshly cut stumps. This treatment cost $24.81 per acre, including the cutting. Almost as good results were obtained with Esteron 245 used as a foliage spray, at a cost of $12.68 per acre.

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Periodicity and Growth of Sugar Maple Surface Layer Roots[1]

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From observations on the root growth of sugar maple made in two localities in central New York during 1948 and 1949, following some preliminary work in 1947, certain deductions may be drawn as to periodicity of growth and the influence of various environmental factors on the inherent growth pattern.

Sugar maple (*Acer saccharum* Marsh.) was selected because, although one of the most important tree species in the eastern United States, it has been nearly overlooked by preceding root investigators. The study assumed that, in the growth of forest trees, root growth is to be compared to crown growth in importance.

Since many investigators have reported that the greatest concentration of absorbing roots is in the upper part of the mantle, this investigation was limited to the root tips located in the upper one inch of soil. The stands studied were of two age classes—an even-aged maple woodlot of about 50 years at Camillus, N. Y., and a 35-year-old maple plantation at the Experiment Station of the New York State College of Forestry, near Syracuse. Five 0.1-acre plots were selected in the Camillus woodlot; two 0.1-acre plots in the plantation at the station. Continuous periodic measurements of soil moisture and soil temperature were made for each locality (Tables 1 and 2). Soil samples from each plot were analyzed both in the field and laboratory.

Description of Areas

The Camillus woodlot contains a fully stocked stand of about 60 percent sugar maple on an excellent hardwood site. It lies on a gentle, north slope in a well protected situation. The Experiment Station plantation contains a somewhat smaller stocking than the Camillus woodlot, and has had the benefit of several light thinnings. These thinnings probably have been responsible for bringing the diameter growth rate of the larger trees on the poorer plantation soil up to that of the larger trees at Camillus, where the trees show a greater expression of dominance than in the plantation. The station plantation lies on a gentle, west slope, exposed to prevailing west winds.

At Camillus, the soils have a silty clay loam texture with an average organic matter content of 11 percent in the A_1 horizon. The pore volume averages 65 percent and the volume weight is .89. At no time during the investigation did the soil moisture fall below the wilting percent (20 percent) except on a few isolated areas of thin soil which became dry for short periods. The pH averages 6.4, and there are no signs of mineral deficiencies. The crumb mull structure of the soil is largely due to the activities of the many earthworms. Root growth is common at a depth of 20 inches.

In contrast to this deep, fertile, porous soil of fine texture, high organic matter, and good water-holding capacity, the Station plantation soil is a clay loam, sometimes a clay. The organic matter content is generally less than 5 percent, while the pore volume averages 51 percent and the volume weight is 1.31. During several dry periods, the soil moisture fell below the wilting percent (9.4 percent). The pH is 6.4, the same as the Camillus woodlot, and there are no signs of mineral deficiencies. However, the soil has a firm-to-medium mull structure, and root and earthworm penetration is seldom deeper than 10 inches.

Root Growth Measurement

To understand the measurement of root growth, certain physiological and structural changes involved in root growth should be reviewed. The root tip growth zone consists of three parts, the region of cell division, region of cell enlargement, and the root hair zone. The

Table 1.—Maximum and Minimum Temperature (Surface Inch) and Soil Moisture Percent (Surface Four Inches) of Camillus Woodlot Soil During 1947-1949

Date	Temperature		Moisture: percent by weight
	Minimum	Maximum	
	Degrees F.		
Aug. 6, 1947			37
20			43
Sept. 10	57.0		36
Oct. 8	37.5		38
22	43.5		30
Nov. 7	41.0		46
26	34.5		
Dec. 10	32.0		51
Mar. 25, 1948	29.0		50
Apr. 8	32.5		48
19	34.0	54.5	44
27	39.0	64.5	
June 10	41.0	68.0	49
26	56.5	69.5	47
July 17	57.0	72.0	48
Aug. 3	58.0	70.5	43
20	54.0	66.0	48
30	60.0	75.0	38
Sept. 14	53.0	69.0	38
Oct. 6	41.5	65.0	51
27	38.0	54.5	41
Nov. 24	40.5	59.5	47
Jan. 16, 1949	32.5	45.0	
Feb. 16	34.5	44.5	
Mar. 23	34.5	45.5	
Apr. 12	36.0	55.5	
26	36.0	57.0	

[1] Condensed from a thesis presented for the Ph.D. degree at the College of Forestry, State University of New York, Syracuse.

TABLE 2.—MAXIMUM AND MINIMUM TEMPERATURE (SURFACE INCH) AND SOIL MOISTURE PERCENT (SURFACE FOUR INCHES) OF THE STATION PLANTATION SOIL DURING 1947-1949

Date	Temperature		Moisture percent by weight
	Minimum	Maximum	
	Degrees F.		
Aug. 13, 1947			13
27	61.0		13
Sept. 10	55.5		9
Oct. 8	47.0		9
Nov. 5	38.5		19
19	31.5		22
Dec. 3	30.5		27
17	30.0		
Mar. 22, 1948	30.0		23
Apr. 6	31.5		26
21	32.5	61.0	26
29	38.0	69.0	27
June 11	39.5	65.0	28
27	51.0	70.5	29
July 15	57.0	73.0	14
Aug. 3	59.0	70.5	13
11			18
19	55.0	67.0	
28	60.0	74.0	10
Sept. 14	54.0	74.5	9
29	46.0	67.5	8
Oct. 4	42.5	63.5	10
28	40.5	56.0	18
Nov. 24	40.5	59.0	
Dec. 6			27
Jan. 16, 1949	32.0		
Feb. 10	30.0	43.0	
Mar. 23	29.0	47.5	
31	36.5	55.0	
Apr. 12	44.5	56.0	
25	35.0	59.0	

region of cell division is usually white or yellow in color, seldom over one millimeter long, and covered by a white, protective root cap. The region of cell enlargement, where most increase in length occurs, is usually white and is several millimeters, but seldom more than one centimeter, long. The root hair zone lies from a few millimeters to several centimeters farther back. The root color behind the growth region is dark and varies by species.

The division of meristematic cells and subsequent elongation results in the projection of the growing region and root cap through the soil, and accounts for the length growth of the root. There is no forward progression through the soil of root hairs, so only a few millimeters of the root tip grow through the soil. New root hairs are formed as new soil is reached, while the older root hairs progressively die.

As the growth region progresses through the soil, maturation of the older tissue, in and behind the root hair zone, keeps pace, marked by the formation of dark colors. The rate of maturation is not necessarily the same as growth rate; thus, at certain seasons the growth rate, indicated by color changes of the root, appears to be accelerated or decelerated in comparison with other seasons. If the rate of maturation were known, or if it were constant, it would be easier to determine the growth rate. Engler (2), in 1903, in year-around root studies, found that hardwood root tips turned brown in from three to six weeks, turning faster in the summer.

Lateral roots of trees are initiated in the pericycle when meristematic cells enlarge radially and divide tangentially. Lateral roots usually form in the region of cell maturation just behind or in the root hair zone. Since the pericycle does not persist long after secondary thickening takes place, lateral root initiation is limited to a short period when the parent tissue is young.

This paper deals with the primary length growth and lateral root development. Secondary thickening is not considered.

Methods of Investigation

Numerous methods of investigating root growth have been devised. Because of the difficulty in observing the environment of the roots, and yet keeping it unchanged, no method has proved wholly satisfactory.

Direct observation of the root in place, or dug out, is probably the oldest and simplest method of root observation. This requires familiarity with the roots under observation and knowledge of morphological indicators of growth, and will not yield exact data. Other methods of root observation include: measurement of number of root tips and total length growth of roots of seedlings; determination of average rate of growth by dividing the total root length by the tree age; and various types of root observation boxes set in trenches. Other investigators have used horizontal and vertical glass plates to measure the growth of adjacent roots, tied string around roots for reference marks, and used small wooden pegs as growth markers. All these methods either provide limited information or cause changes in the root environment.

In 1939, Ladefoged (4) reported successful measurements of root growth in Denmark. He dug into the soil to find growing roots, placed a mark on the root as a reference point, and measured the distance from the mark to the root tip with calipers. A stake was left to mark the location of the root. The soil is obviously disturbed in this method, but Ladefoged justified his results by use of large numbers of samples, low percent deviations in results, and similar results on adjacent areas.

In addition to the measurement of length growth, which has been the approach of most root investigators, the number of growing root tips also have been measured. The advantage of measuring number of growing root tips over measuring length growth is that the former is very nearly a measure of absorp-

tive capacity of the root. On the other hand, length growth measurements are probably more important in younger plants, for length growth indicates the rate at which new areas of soil moisture and nutrients for growth are made available.

Plan of Investigation

During the summer and fall of 1947, the measurement of length growth of sugar maple roots was attempted with little success. A vertical glass plate, placed parallel to the root, was used with a wire reference mark on the root, a scribe for marking growth progress on the glass plate, and calipers for measurement. The inherent growth form of sugar maple roots, which have numerous rootlets formed immediately behind the main root tip, would not allow the root to lie close enough to the glass plate to be seen. Thus the root had to be excavated for each measurement, and soon the drying effect of warm day observations was noted. A loss of soil structure was also observed, especially on wet days. Furthermore, the wire reference markers sometimes slipped when the root was handled, the wire eventually began to disintegrate, and there was always the danger of girdling injury by drawing the wire too tight.

In the early spring of 1948, the vertical glass plate and wire markers were discarded, and small pieces of glass were used for the reference mark and for marking root progress through the soil. Excavation of the soil in front of the root only was made for growth observations. Thus root handling was avoided, but soil structure was still considerably changed, sometimes to the extent that rains washed soil away from the root tip.

A third and more successful measurement of root growth was used from the spring of 1948 to the spring of 1949. In each plot, an area was arbitrarily selected in the center of a group of sugar maple trees so that the danger of examining roots of another species was considerably reduced. Within these small areas, ten root tips from the surface soil were dug out and examined with a 43-power microscope. The number of root tips was counted on the root and rootlets back a distance of one inch from the foremost tip. These tips were classified in three groups; white and in a growing condition; brown, not growing; and black, completely suberized. These measurements were made periodically through the year, especially after changes of weather conditions and seasons.

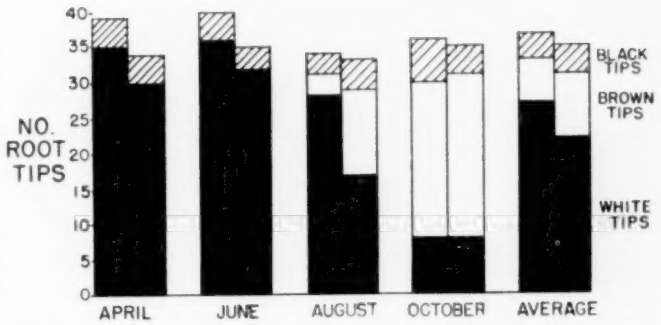

FIG. 1. Average number and classification of root tips in first inch behind the foremost tip. Left bars represent Camillus woodlot and right bars represent Station plantation. The root tips turned brown faster in the plantation than in the woodlot, indicating a more rapid decrease in summer root growth in the former. Each month is represented by 70 samples.

While this method of root growth measurement fails to give exact length-growth data, it is obvious that a more nearly total view of root growth is acquired. This is particularly true during the summer, when many roots are not growing. The investigator, however, must have a reasonable knowledge of local tree roots to know with what species he is working.

Root Growth at Camillus Woodlot

A long period of warm weather starting on March 15, 1948, removed the last snow and caused a fast upsurge in root growth. Average length growth of roots, determined by dividing the length of white tips on March 31 by sixteen (days of warm weather), was just under 1 mm. per day. The maximum length growth was 3 mm. a day. At no period of the year was there greater length growth.

Lateral root formation immediately became prominent also, some lateral roots starting growth less than 2 mm. behind the tip of new growth. By the latter part of April, microscopic measurements of 50 roots (10 on each of the five plots) showed that there was an average of 39 root tips on the root and rootlets in the first inch behind the foremost tip. An indication of the growth at this period is disclosed by the fact that an average of 35 of these root tips in the first inch were growing white tips, while the remaining four were suberized black tips (Fig. 1).

At this time in the spring, the process of suberization (part of the maturation process) had begun on the part of the root representing the earliest spring growth. This involves a gradual change in color from white to brown, thus making the measurement of length of new growth somewhat uncertain. However, estimates of new length growth averaged 20 mm. If we assume that suberization commences approximately one month after growth, a reasonable assumption for hardwoods in the spring, according to Engler (2), then this 20 mm. growth occurred in a period of one month or at the rate of 0.6 to 0.7 mm. per day in April.

Further observation of the roots revealed the fact that at least 70 percent of the present year's root growth was not from main root tips of the previous year. Thus

normal spring growth involves the formation of new roots primarily, rather than the extension of old roots.

Root growth measurements in June showed no apparent change from spring growth. During the third week in July, however, several brown root tips were found. This condition seemed to be caused by slowing of growth and the resulting catching up of the suberization process. Engler (2) found that the rate of suberization speeded up to a period of 3 weeks for hardwoods in the summer. Nightingale (5), in 1935, found that maturation of growing tissue proceeded rapidly in apple and peach roots at temperatures above 65 F. Since a maximum temperature of 72 F. was recorded for the period from June 26 to July 17, temperature may have been significant in the change of root growth.

Observations during the latter part of July and August revealed that on higher and drier parts of one of the plots, the soil was apparently at or below the wilting percent for short periods. The root tips found in these isolated spots were shriveled in varying degrees, sometimes to the extent that the cortex was broken. The color varied from white to yellow, indicating that the tips were in a growing condition when lack of moisture caused a loss of turgidity with resultant shrinking. When ample moisture became available, these damaged root tips were generally replaced by new root tips.

The number of brown root tips, shown in Figure 1, clearly reveals the extent of root dormancy, commencing in August and extending throughout the fall. These brown roots indicate such slow growth that the normal maturation rate completely overtook new tissue formation. Even the new tissue on the white root tips was so small that accurate measurements could not generally be obtained. Actually the conditions pictured in Figure 1 for October were approximately reached on September 1, although full data were not obtained at that time.

While few winter observations were made, there was no indication that root growth deviated much from the pattern of fall growth. At no time was over a half-inch of frost in the soil, and often there was none. On January 10, 1949, after a period of about ten days of snow cover, root growth appeared to be in as vigorous a stage as it was in the fall. One root had nearly an inch of new growth. While the maturation rate is undoubtedly much slower in the winter than during other periods of the year, there seems no denying that some of this growth occurred in the winter. The average minimum winter soil temperature was 31.5 F.; this shows that some roots grow at temperatures near freezing.

On February 10, after varying degrees of snow cover and lack of cover, the snow was completely gone and there was some frost in the upper quarter-inch of soil. Estimates of root growth revealed that there were about 20 percent of growing white tips in the first inch back of the foremost tip, compared with about 25 percent of non-growing brown tips and 55 percent of black suberized tips. In comparison with fall growth, there was a sharp decrease of brown tips and increase of black tips while the number of white tips remained about the same. This merely reflects the final suberization process of these former brown root tips. Nearly one inch of new growth was found on one root.

New growth may grade directly into black roots, rather than into the brown color first. This indicates that the root was a new lateral root, and not the result of yearlong growth. This fact, plus the observed new tips from dried, broken roots in the fall, plus the observed formation of new tips in the spring demonstrate that replacement of root tips is a normal occurrence at least once, and often several times, during the year.

On March 21, warm spring weather came, and by the end of March, root growth appeared to have reached an intensity comparable to the previous spring. Thus spring root growth was about a week later in starting in 1949 than in 1948, coming in both cases with warm weather.

In all the observations of root growth in the Camillus woodlot, there was little or no significant difference between the five plots that were used.

Root Growth at Station Plantation

Little information on root growth was obtained in 1947, except that there was some growth in the summer and in November. No observations were made in September nor during the following winter. However, no root growth occurred during most of the extremely dry month of October when the soil moisture was below the wilting percent.

In the spring of 1948, root growth followed very closely the pattern of Camillus woodlot root growth. In summer, however, brown root tips were noted 3 weeks prior to their appearance at Camillus. This seems to be correlated with earlier increased soil temperature in the more exposed plantation soil. In July and August, many roots had shriveled and broken cortex, apparently because soil moisture was lacking in parts of the soil. The soil moisture of the upper 4 inches of soil was generally just above the wilting percent during this period, but it was noted that more moisture and better root growth prevailed at a depth of 2 inches than in the top inch.

The soil moisture fell below the wilting percent in the middle of September, and no root growth whatsoever was found. Three days of precipitation followed, and 2 days later, there was a complete transformation in root activity. Formation and growth of lateral roots was found in every area examined, and was very similar in appearance and amount to the spring root growth. One root had grown 15 mm., probably in 4 days, the fastest single root growth observed all year at the plantation. Most of the new roots were newly formed, rather than extension of old roots. Twice more in the next

2 weeks the soil moisture fell below the wilting percent with stoppage of root growth, and each time new root growth started immediately with the advent of available soil moisture. With sufficient soil moisture in October, fall root growth followed the same general pattern as in the Camillus woodlot.

Winter root growth at the plantation seemed to be a little less than at the Camillus woodlot, but otherwise followed about the same pattern. This result is not surprising since the average winter minimum soil temperature was 29° F., 2.5° F. less than that at Camillus.

TABLE 3.—AMOUNT OF GROWTH OF VARIOUS TREE ORGANS AT THE CAMILLUS WOODLOT AND THE STATION PLANTATION IN 1948

Date	Root growth (Camillus)	Root growth (Station)	Shoot growth (Station)	Cambial activity (both)	Leaves present (both)
Jan.	+	+	0	0	0
Feb.	+	+	0	0	0
Mar.	+	+	0	0	0
	+++	+++			
Apr.	+++	+++	0	0	++
May	+++	+++	+++	+++	++
June	+++	+++	+++	+++	++
July	+	+	+	+	++
Aug.	+	+	+	+	++
			0		
Sept.	+	+	0	0	++
		0			
Oct.	+	++	0	0	0
Nov.	+	+	0	0	0
Dec.	+	+	0	0	0
No. of months	12	11.5	3.5	4	6

Great amount = (++++) Little amount = (+)
Medium amount = (+++) None = (0)

Estimates of Yearly Root Growth

Length growth of roots in both localities averaged from 0.6 to about 1 mm. per day from the middle of March to the end of June, with little growth thereafter. Therefore the yearly length growth of the investigated roots is about three to four inches. Since the greatest production of new lateral roots occurs during this 3½-month period, it is safe to estimate that over 80 percent of the total year's root growth occurs in this period.

Mycorrhizae and Root Hairs

Mycorrhizae were found on at least 95 percent of the sugar maple roots examined in all plots. These mycorrhizae were found in all seasons of the year when the roots were growing, and they were destroyed in dry soil just as the roots were. It is significant that the mycorrhizae were widespread, although individual development was not great on these relatively fertile soils of relatively high pH. Much previous mycorrhizae literature is not in agreement with this observation. Mycorrhizae have been known both to increase and decrease root growth under certain circumstances, but their influence was not determined at Camillus or the Station.

Root hairs, averaging about 0.1 mm. in length, were found to some extent on over 75 percent of the examined roots. Root hairs were found when the roots were growing, and were not noticed during dry periods when the roots were not growing. In the spring root hairs were found on new growth, old growth, mycorrhizae, and non-mycorrhizal roots.

Growth of Aerial Portions of the Tree

Shoot growth occurred at the plantation in 1948 approximately from May 1 to August 15. Shoot growth was about 85 percent complete by June 15, however. Shoot growth stopped in the summer at nearly the same time that root growth was slowing down. About half of the yearly root growth occurred during the period of shoot growth. Otherwise there is no correlation between shoot and root growth (Table 3).

A special dial gauge measuring instrument, similar to the one described by Tryon and Finn [8] in 1949, was used to measure tree expansion due to cambial activity on all plots. Cambial activity occurred from about May 1 to August 31, based on data obtained in 1948 and 1949, but was approximately 80 percent complete on July 1. There was less activity in intermediate trees, which stopped around July 15, than in codominant trees. Cambial activity nearly paralleled shoot growth, but it lasted a half-month longer. Therefore, it can be compared with root growth in a similar way to the comparison of shoot growth and root growth.

The leaves began to unfold from the buds about 3 weeks after the beginning of active spring root growth, and fell 6 months later. Thus most of the maximum root growth coincided with maximum leaf development.

In general it may be said that the growth activities of shoots, cambium, leaves, and root appeared to be independent of each other, but the maximum periods of growth of all these portions of the tree occurred at about the same time in both localities. Thus, these various growth organs may have competed heavily with the roots for growth materials.

Seasonal Periodicity

Periodicity is generally thought of as a set pattern of growth caused by internal (inherent) factors, and the influence of the plant environment acts only to alter this predetermined pattern. There are common examples of seasonal periodicity in plants; the seasonal growth of shoots, cambial activity, leaves, etc. Can this not also apply to root growth?

Sugar maple root growth is of course influenced by various environmental factors. Root growth in the winter, the upsurge in spring root growth, and slowing of root growth in the summer all seem primarily correlated with soil temperature. Further root growth stoppage in the summer and fall

is correlated with lack of soil moisture.

One root growth reaction, however, is difficult to explain on the basis of environmental factors. After soil moisture and soil temperature reached autumn conditions, similar to conditions present for maximum spring growth, there was no great upsurge in fall growth, compared to spring growth. This cannot be attributed to lack of carbohydrate growth materials, since these were available for spring growth before the leaves unfolded. Therefore, root growth of sugar maple appears to be governed by an internal growth pattern, which in turn is influenced by environmental factors.

Discussion

Most investigators of root growth have reported good root growth periods in the spring and fall, separated by dormant or semi-dormant periods in the summer and winter. This dormancy has usually been attributed to lack of moisture in the summer and cold weather in the winter.

In both localities, the root growth was by far the most vigorous in the spring, coming with a sudden increase in soil temperature. While it was evident that some root growth occurred during the low winter temperatures, apparently maximum growth can occur only with somewhat higher temperatures. This is not surprising, and is quite in agreement with most previous root investigations.

Beginning in early summer, root growth started to retard, this process coming earlier in the more exposed, thin soil of the Station plantation. While some of this slowdown apparently can be attributed to high soil temperature, most of it is due to other causes. Soil moisture, while below the field capacity, showed no influence on root growth until it approached the wilting percent. On the deep coarse mull of the protected Camillus woodlot, lack of available soil moisture for root growth occurred rarely and only in isolated spots of thin soil, while root growth was often partly or entirely interrupted by lack of available soil moisture on the poorer Station plantation.

In the fall, after soil temperature and soil moisture of both areas reached the same conditions that existed with maximum spring growth, root growth made only a slight increase. Thus it is apparent that the periodicity of sugar maple root growth in these stands was the cause of much of the decrease in the summer and fall. While most preceding investigators have found more root growth in the spring than fall, there are some exceptions. For example, Petersen (6) found that there generally was more root growth in hardwood seedlings in the fall than in the spring in Denmark in 1904. In the same year, Engler (2) found just the reverse in Switzerland.

In the mild winter of 1948-1949, there was some root growth on both experimental areas. This is not too surprising, considering that the minimum temperature was 29° F., nor is it contradictory to most earlier root studies. Several reports of some root growth in mild winters in France and Germany were made in the nineteenth century. Engler (2) found root growth of several hardwood species in a mild winter in Switzerland; Harris (3) found winter root growth on apple and filbert trees in British Columbia valleys, but found no growth in the higher, colder valleys; Ratjer (7) found some winter growth of apple tree roots in Maryland; Rogers (7) found winter root growth of apple trees in England; and Ladefoged (4) found growth of European beech roots, but not other tree roots, in a mild winter, in Denmark. It should be noted that all winter growth of tree roots has been reported either in regions of mild climates or in mild winters. The climate of central New York is probably about as rigorous as any other place where winter root growth has been found.

In order to find whether or not the general pattern of root growth found in this study can be expected normally, the seasonal weather was compared with normal weather conditions. This comparison was made by using the weather data, based on observations of 32 to 47 years, compiled by the Syracuse branch of the U. S. Weather Bureau. The weather station was located within 9 miles of the Station plantation and was about 300 feet lower in elevation, while the Camillus woodlot was even closer in both distance and elevation.

This comparison showed that root growth commenced in the spring of 1948 about a week earlier than normally might be expected, since warm weather arrived about a week early. The summer and fall were a little warmer and considerably drier than normal. Thus root growth should be expected to continue at a rapid rate somewhat later in the summer than it did in 1948. Normally lack of soil moisture should not be expected to hinder root growth at Camillus, while some soil drying and root growth stoppage must be expected at the Station.

The winter of 1948-1949 was very mild, with less than normal snow cover, and there was some root growth in both localities. During the winter of 1947-1948, when root growth was not measured, the weather was somewhat colder than normal, but the minimum soil temperature was reduced less than 2° F. below the minimum soil temperature of the mild winter of 1948-1949. This high minimum temperature in the previous cold winter was probably due to the unbroken snow cover which lasted throughout the winter. In a normal winter, when there are several days without snow cover, a lower minimum soil temperature should be expected. Thus, it is undetermined whether the roots grow in the upper inch of soil at the investigated areas in normal winters, but it is probable that there is normally some winter growth, at least during the more favorable periods of the winter.

Summary

1. Sugar maple root growth was measured in 1947-1949 in young stands on two different sites in central New York. Soil mois-

ture and soil temperature were recorded periodically during most of the year, and other soil characteristics were measured.

2. The roots grew throughout a mild winter. Root growth was year-round on a deep coarse mull soil, but early fall drought halted growth on a poor shallow soil. Most of the year's root growth consisted of formation of many new root tips, with little length growth. Root growth occurred primarily in the spring.

3. Since there was much spring root growth and little fall root growth, under similar soil environmental conditions, it was concluded that sugar maple roots grow according to an inherent growth pattern, which in turn is influenced by environmental factors.

4. Low soil moisture and high soil temperature caused root growth to slow in the summer, while winter root growth and the vigorous spring root growth were contingent on soil temperature.

5. Shoot growth, cambial activity, leaf activity, and root growth demonstrated no correlations, except that the maximum growth of each occurred during the same period of the year.

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Massachusetts Offers Arboriculture Course

Gordon King, assistant professor of arboriculture at the University of Massachusetts, Amherst, reports that since the inauguration of a two-year course in arboriculture a few years ago all students have had jobs before graduation. The course trains men for jobs such as: foremen and salesmen for arboriculture firms; utility line clearance foremen; deputy tree wardens; city foresters; tree care on estates, parks, highways, public institutions; and managers of their own service organization for the practice of arboriculture.

The present two-year course at the University of Massachusetts is an expansion of the first shade tree course offered in the United States, given in 1895 by this school. The present program was initiated by the Massachusetts Arborists' Association and the Massachusetts Tree Wardens' and Foresters' Association in collaboration with the university.

Classes are limited to 20 students, all of whom must have passed physical, mental, and business objective tests.

Courses include such basic ones as soil management, fertilization, tree and shrub materials, diseases and insect pests of plants, and specialized courses including landscape construction problems, woodland management, shade tree surveys and cost estimates, plant propagation, tree climbing, business English, and arboriculture — diagnosis and control.

Annually in March a conference of one week's duration is held on the campus for tree wardens and arborists.

Rate of Deterioration of Beetle-Killed Engelmann Spruce[1]

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DURING THE COURSE of a severe wind storm in mid-June 1939, small groups and patches of Engelmann spruce (*Picea engelmanni* Parry) were blown down on several of the national forests[3] in Colorado. The Engelmann spruce beetle (*Dendroctonus engelmanni* Hopk.), already present in endemic numbers, built up comparatively large populations in the wind-thrown trees and spread from them into the surrounding stands. Timber killed by the resulting infestation, which became evident in 1942, was estimated at 4 billion board feet by the end of 1948 (*7, 12*), at which time the infestation was still in progress. Approximately three-fourths of this loss is on the White River Forest and the remainder on the Grand Mesa, Gunnison, Routt, San Juan, Uncompahgre, and Arapaho National Forests in western Colorado.

The dead timber presents a major salvage problem. A small portion has been cut for lumber and pulpwood, but immediate salvage of the bulk of it has proved to be impractical. Salvage possibilities thus depend upon how long the timber can be expected to remain in a usable condition. Examinations and experience in logging have shown that practically all the killed trees are still standing and that with the exception of a few cases of basal sap rot they are still sound.

Studies to obtain information on the rate of deterioration in such dead timber were undertaken in 1948 and were conducted for the most part in Utah, where stands of killed Engelmann spruce from an older infestation by the same species of beetles were available.

Condition of Bark Beetle-Killed Spruce in Utah

The spruce stands investigated are situated on the Aquarius Plateau and adjacent Boulder Mountain in the Dixie National Forest in southern Utah and extend over a gross area of about 115,000 acres. At the time of attack they were uneven-aged, with the oldest trees about 325 years of age, as determined by ring counts on stumps.

History of beetle infestation.—According to Forest Service records the beetle invasion began between 1916 and 1918. Ample evidence is still present that it started as the result of a wind storm that blew down small patches of spruce throughout the area. By 1924 the infestation was observed to be on the decline, and it ended about

FIG. 1.—*A* and *B*. Stands of Engelmann spruce on Boulder Mountain, Dixie National Forest, Utah, killed by *Dendroctonus engelmanni* about 25 years ago. The live trees in the stands are relatively young individuals, which were so small at the time of the infestation they were not killed by the beetles.

[1] Report of a study made under the Research and Marketing Act of 1946.

[2] The writer wishes to express his appreciation to Willis W. Wagener for suggestions and advice in planning the study and preparing the report. Acknowledgment is made to the U. S. Forest Service in Regions 2 and 4 for their cooperation during the course of the field work, and to N. D. Wygant, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, for supplying information on the beetle infestation in Colorado.

1928 when the entire spruce stand, except for the youngest trees, on the Aquarius Plateau and Boulder Mountain had been killed. Thus, most of the trees have been dead about 25 years. This was substantiated by the finding that numerous increment cores taken in 1948 from living, originally suppressed trees that had escaped attack because of their small size showed increased diameter growth from about 1923.

Salvage of dead trees. Cutting of the dead spruce on a small scale by local ranchers for corral poles, fence and house logs, and other farm uses has occurred practically ever since the beetles killed the trees. Starting about 1935, a large volume of the smaller trees has annually been removed for mine props. Cutting of the larger or sawlogs sizes for lumber began in 1944. The largest volume, however, is at present being removed for mine props. Practically all the Aquarius Plateau has now been cut over and a start was made in the stands on Boulder Mountain in 1948.

Study plots. Because practically all the dead spruce on the Aquarius Plateau had been cut over by 1948, the study was conducted on Boulder Mountain. Only one road permitted access to the mountain. It is situated on the southwest side and extends back from the rim about 4 miles. Therefore it was necessary to confine the study area within reasonable walking distance of the road, or over an area of approximately 12 square miles. In this vicinity the rim is not nearly so steep, rocky, and high as on other parts of the mountain. Individual plots on which data were obtained within this area were on both the slope of the rim and on the plateau above it.

All beetle-killed trees, both standing and down, totaling 2,560, on 100 tenth-acre sample plots along 19 different compass courses, were tallied and data taken on them. Since evidence of the beetles was still plainly visible on the surface of the wood, it was possible to distinguish between trees killed by these insects and occasional individuals that had died from various causes prior to the infestation.

The spruce on Boulder Mountain occurs in patches of irregular size and shape, occupying about 40 percent of the total area, according to Gould (5), and interspersed with open parks and meadows. Since most of it is on unsurveyed land, land lines were not utilized in locating sample plots. Instead, plots were taken at 5-chain intervals, determined by chaining or pacing, on compass lines begun at the most accessible edge of individual stands adjacent to the road and directed along whichever of the eight cardinal compass points appeared to give the most satisfactory traverse through the timber to avoid major openings. Usually, only one line of plots was run through a stand unless it was a large one. In this manner, the timber within working distance of the road was progressively covered. After the plot work was completed on the west side, observations were made on horseback over a large area on the southeastern side of the mountain. This inspection confirmed the supposition that the dead stands there did not differ from those covered in the sampling.

Results

Length of time trees remain standing. The tabular results of the plot studies, involving the number of beetle-killed trees standing and down, arranged in order of size classes, are shown in Table 1. Although dead for about 25 years, in 1948 84 percent of the beetle-killed trees of all sizes were still standing on Boulder Mountain and only 16 percent were down. A somewhat higher percentage of trees had dropped out in the smaller diameter classes than in the larger ones. Typical stands of dead spruce as they appeared in 1948 are shown in Figures 1.A and 1.B.

Data were obtained on the relative time of fall for 414 of the 421 down trees on all the plots. The time was recorded as "recent" and "old." Those trees regarded as "recent" falls had not been down more than three or four years, as nearly as could be determined, and those classified as "old" had been down for a longer period of time.

TABLE 1. TABULATIONS OF BEETLE-KILLED ENGELMANN SPRUCE ON BOULDER MOUNTAIN, DIXIE NATIONAL FOREST, UTAH, IN 1948

Size classes	D.b.h. classes[1] (outside bark)	Number of trees			Percentage of trees standing
		Total	Standing	Down	
	3	6	5	1	83
Poles	4-5	83	63	20	76
	6-7	255	205	50	80
	8-9	358	285	73	80
Totals	3-9	702	558	144	80
	10-11	396	333	63	84
Small sawlogs	12-13	379	305	65	82
	14-15	341	290	51	85
Totals	10-15	1107	928	179	84
	16-17	226	203	23	90
	18-19	187	158	29	85
Medium sawlogs	20-21	118	103	15	87
	22-23	85	77	8	91
	24-25	64	50	14	78
Totals	16-25	680	591	89	87
	26-27	33	31	2	94
Large sawlogs	28-29	19	16	3	84
	30-31	10	9	1	90
	32 and over	9	6	3	67
Totals	26-32+	71	62	9	87
Grand totals		2560	2189	421	84

[1] In the segregation of the size classes, the division between poles and small sawlogs has been made at the 10-inch diameter class because five sixths of that diameter are the smallest ones marked for sawlog cutting in the Rocky Mountain Region. In the management of Englemann spruce in the U. S. Forest Service, no designated sawlog classification has been set up. The sawlog classification here used is therefore an arbitrary one.

On this basis, 132 (32 percent) of the trees had fallen recently and 282 (68 percent) had been down for an indefinite number of years. Judged from the condition of the down trees with regard to the percentage of bark sloughed off, loss of twigs and branches, weathering, and state of decay, it seemed apparent that most of the dropout to date had taken place gradually over a number of years.

Several root-rot fungi occur in living spruce and it seems possible that these organisms may have greatly weakened the root systems of some of the trees before they were killed by the beetles. If this was the case, it may account for some of the earlier dropout of the trees.

On the basis of the data obtained and observations, it did not appear that the rate of fall of the dead trees had been markedly accelerated in recent years. Considering the present condition of the stand, it is believed that relatively few of the trees fell during the first 10 years after the beetles killed them. All indications suggest that in stands not removed by salvage the dropout will continue to be gradual for a number of years in the future.

Causes of fall. Factors considered responsible for the dropout of the dead trees are shown in Table 9.

Wind throw (Fig. 2A), independent of weakening from decay, has not been an important factor in the dropout of the spruce. Fungi are by far the most important factor to date, and root and basal rots combined account for the loss of 77 percent of the

TABLE 9.—FACTORS CAUSING FALL OF THE BEETLE-KILLED UTAH SPRUCE

Causes	Trees	
	Number	Percentage
Basal rots	153	38
Root rots	156	37
Basal and root rots in combination	7	2
Uprooted by wind	93	23
Broken off by wind	17	4
Knocked down by falling trees	29	7

[1] Most of these trees contained heart rot of the bole caused by *Fomes pini*, which was present in the trees before the beetles killed them.

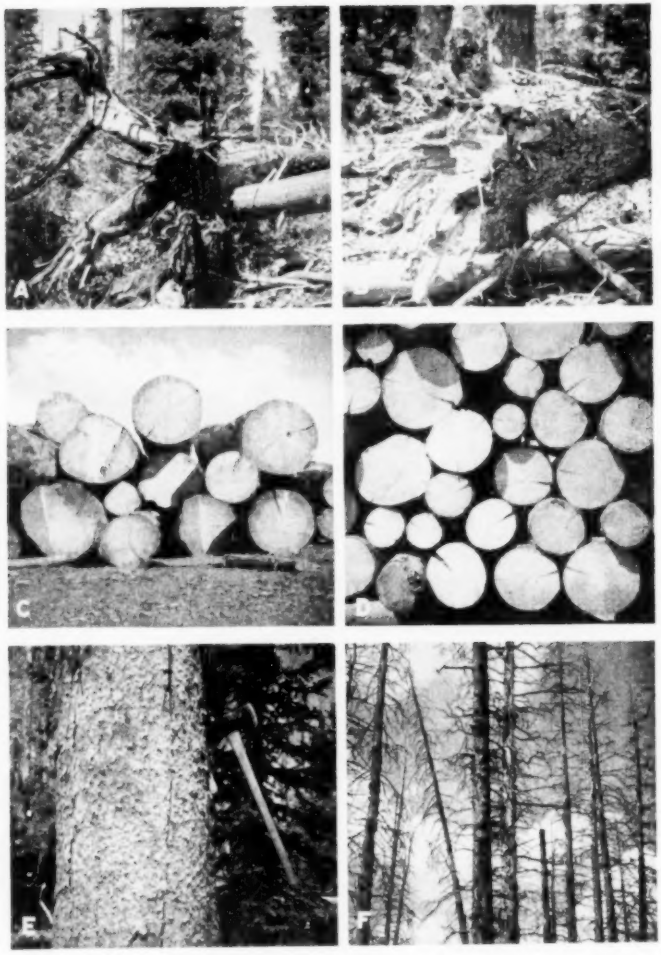

FIG. 2.—A.—A wind-thrown spruce snag, Boulder Mountain, Dixie National Forest. Relatively few wind-thrown trees were observed in the beetle-killed Utah spruce. A high percentage of the root systems of such trees recently blown down were still sound.

B.—A fallen beetle-killed spruce in Utah with butt rot caused by *Fomes pinicola*. The decay caused by this fungus rarely extended upward in the bole more than a foot. In most cases the trees were either almost or completely rotted off at the base before they fell.

C.—Season check in spruce logs in Utah. The trees from which the logs were cut a few days previously have been dead about 25 years. Evidently checking practically ceases after the wood becomes well dried out. Compare the season check in this illustration with that shown in Fig. 2 D.

D.—Season check in spruce pulpwood on the White River Plateau in Colorado. The main period of beetle kill in the stands on this area occurred between 1942 and 1946, or 2 to 6 years previously.

E.—Bark retention on a beetle-killed spruce in Utah. This is typical for a high percentage of the trees. Over 40 percent of the dead trees still have over 90 percent of their bark largely intact.

F.—Twig and branch retention of beetle-killed spruce in Utah, dead about 25 years. See also some of the trees in the foreground in Fig. 1-B.

total of all trees that have gone down. At the present time basal rots, which involve both the sapwood and heartwood, and root rots appear to be about equally important. *Fomes pinicola* (Fr.) Cke. was the most common basal-rot fungus observed (Fig. 2,B). Practically all the root rots were of the stringy type and a number of species probably were involved. Many trees were either almost or completely rotted off at their bases before they fell.

Each of the 100 plots was classified as to degree of slope, aspect, and character of the soil with regard to the presence of rocks and boulders. No correlation of significance between any of these factors and the rate of dropout was found.

Decay in standing and down trees.—The trunks of the standing trees in Utah were found to be perfectly sound except for an occasional individual with basal sapwood decay that rarely extended more than a foot or two above ground level. No decay that entered following the beetle attack was found above about 4 feet. Heart rots and butt rots were present in some of the trees prior to the time they were killed by the beetles. Because of the very dry condition of the trees since their death, it appears very unlikely that any of the decay fungi involved have made any progress of consequence in the dead trees, except near ground level.

Scattered throughout the beetle-killed spruce are old, decorticated snags that are still perfectly sound. Their condition indicates that these trees died long before the beetles invaded the stands. It is estimated that a fairly large percentage of them have been dead at least 40 or 50 years, and some possibly longer. All evidence obtained indicates that the spruce will remain sound as long as it remains standing.

No concrete data were obtained on the rate of deterioration of the dead spruce after it had fallen, because the date of fall could not be determined. However, it was evident from observations and the experience of Utah spruce operators questioned on the subject that decay starts in down trees within a few years after they fall. Trees directly in contact with the soil appear to decay somewhat faster than those supported off the ground by fallen trunks. Decay was observed to start around season checks which collect rain water.

TABLE 3.—WOOD DECAY FUNGI[1] FOUND IN THE BEETLE KILLED SPRUCE IN UTAH

Decay organism	Prevalence	Notes
Armillaria mellea Fr.	Fairly common	Basal and root rot of standing trees.
Fomes pini (Fr.) Karst.	Fairly common	Present in trees before they died. Caused some windbreak and basal rot of standing trees. Decay of down trees.
F. pinicola (Fr.) Cke.	Very common	Basal rot in standing trees, also decay of down trees.
F. nigrolimitatus (Romanell) Egel.	Common	Decay of down trees, also basal rot of standing trees.
Lenzites sepiaria Fr.	Fairly common	Found only on down trees.
Polyporus albolateralis Ell. & Ev.	Very common	On down trees only.
P. circinatus Fr.	Fairly common	Root and basal rot. Present in many trees before they are killed.
P. leucospongia Cke. & Hark.	Fairly common	On decorticated trees down for some time.
P. ursinus Lloyd	Common	Found only on down trees.
Polyporus abietinus Fr.	Fairly common	Found only on down trees.
Poria (sp.?)	Occasional	Found only on down trees.
Stereum abietinum Fr.	Fairly common	Found only on down trees.
Trametes serialis Fr.	Occasional	Found only on down trees.
T. subiformis Peck	Common	Found only on down trees.

[1] Identifications by Ross W. Davidson, Division of Forest Pathology, U. S. Department of Agriculture.

The 14 fungi reported here (Table 3) as causing dropout of the dead spruce and decay of the down trees in Utah include 12 species that were identified from sporophores and two by the character of the decay caused by them. In the high elevations where Engelmann spruce grows, only occasional years are favorable from a weather standpoint, particularly with regard to moisture in the form of summer rains, for the production in abundance of sporophores of the decay fungi. The summer of 1948 was relatively unfavorable for the production of these fruiting bodies; consequently the number of species observed and collected probably represents only a fair portion of those which are actually present and which would be found in more favorable years. Time was not available in 1948 to make isolations and cultural studies for identification purposes, particularly of the root-rot and other fungi causing fall of the dead trees.

Moisture content of the dead trees.—Moisture contents of beetle-killed Englemann spruce, obtained with an electrical resistance moisture meter are given in Table 4. Because these instruments are considered good moisture inspection tools if the moisture content is below about 30 percent (*4*, *8*), no attempt was made to obtain moisture content values by the oven-drying method. Moisture contents were obtained from freshly sawn logs in normal operations at the mill. The height of the logs in the trees from which the boards came and usually the position of the logs in the tree were not determinable. However, butt, top, and intermediate logs were included and therefore the data are believed representative of what would be found in general sampling.

The significant fact from Table 4 is that, in killed trees that have been dead for three years or more, the moisture contents of both heart and sapwood have reached such a low level that decay fungi are unable to develop. All but one of the points tested in logs on the Powers operation in Colorado and all at the Taylor operation in Utah gave a moisture reading below 22 percent. Higher moisture readings were obtained at the Rippy Mill because the beetle infestation in that vicinity was more recent than at the Powers operation. According to Hartley (*6*), "decay fungi progress rarely or slowly, if ever, at moisture contents below 25 percent." Presumably the low tem-

TABLE 1.—MOISTURE CONTENT OF BEETLE-KILLED ENGELMANN SPRUCE[1]

National Forest	Mill	Length of time dead	Kind of wood	Number of logs with moisture percentage of: 5-7	8-12	13-17	18-22	23-27	28-32	Over 32	Total No. of logs	Mean moisture percent
White River, Colo.	Rippy	Short some trees still had green needles	Sap			2	8	16	4	9	39	32
			Heart				2	14	4	12	32	33
	Powers	3-5 years; a few recent	Sap		13	9	1				23	13
			Heart		9	28	10			1	48	16
Dixie, Utah	Taylor	About 25 years	Sap	2	46	2					50	10
			Heart	1	40	7	2				50	11

[1] A resistance-type electric moisture meter was used in determining the moisture percentages. Readings with the instrument were taken on boards freshly cut at the mills. Most of the boards at the Rippy Mill were 2 inches thick. All boards at the Powers and Taylor Mills were 1 inch thick. At the Rippy and Powers Mills one sapwood or one heartwood board, or a board containing both kinds of wood, from each log was sampled. At the Taylor Mill the logs were followed through the mill and a single board containing both sapwood and heartwood selected from each log was sampled.

peratures in the Engelmann spruce stands delay decay until the wood becomes too dry for decay fungi to progress. These moisture data explain the observed freedom from decay in beetle-killed Engelmann spruce trees long dead. Some temporary surface wetting of the dead trees occurs as the result of the rather frequent summer thunder storms. However, at that time of the year the Utah and Colorado spruce areas are generally characterized by moderately low relative humidities, bright sun, and more or less wind. These conditions are mainly responsible for the rapid drying out of the trees after they die and for their continuing low moisture content so long as they remain standing. Probably climatic conditions also account for the scarcity of attack by wood-boring insects, since conditions unfavorable for decay are likewise unfavorable for these insects.

Season check, blue stain, and wood borers.—Season check is the only defect of consequence in the dead spruce and this is a factor only when the trees are cut for lumber. Engelmann spruce retains its needles in a green condition for about a year after the beetles have attacked the tree. Considerable checking in Colorado was observed already to have taken place in trees with green needles still attached. It is not known if these green needles continue to transpire and thus possibly aid in the drying out process of the wood.

Checking accompanies the drying out process of the trees and, after the water content of the bole has been reduced to its approximate lowest level under the environmental conditions prevailing in these spruce areas, it appears that no further checking of consequence occurs. Attesting to this is the evidence that season check in the Utah spruce now dead about 25 years (Fig. 2C) is no worse than in the older of the beetle-killed trees on the White River National Forest in Colorado (Fig. 2D) where most of the oldest ones date back to 1942.

Examinations of freshly cut and decked logs in Utah revealed that about 65 percent of the trees have one large season check, 15-20 percent have two, and occasional trees have three large checks. Most of these extend to the center of the tree. About 15 percent of the trees develop no large checks, but instead, numerous small, shallow ones. The latter are nearly all removed in slabs when logs from such trees are sawed. The loss or cull from season check is not high when the logs are sawn into lumber and probably is more or less compensated for by the reduced costs of logging and the trucking of the lumber because of the very light weight and consequent ease of handling this material when compared with logs and lumber cut from green trees.

Blue stain in the dead spruce does not appear to be a serious defect. Practically all, if not all, of this stain is caused by an unidentified species of fungus that probably was carried into the trees by the beetles at the time of their attack. Only that portion of the bole involved in the attack by the insects shows evidence of the stain and the remainder of the sapwood is clear and bright. The stained wood is very pale or light blue in color and is ordinarily not objected to in trade channels.

Exceptionally few of the dead trees have been attacked by wood borers; i.e., the larvae of flathead and roundhead beetles. In the few cases seen, which were light attacks, these insects were mainly confined to the larger trees and in them to the lower portion of the bole. Occasional trees showed some evidence of pin-hole borers (ambrosia beetles). Practically all the defect caused by the borers is in the sapwood and is removed in the slabs when the trees are cut into lumber.

Bark and branch retention.—A high percentage of the bark and branches still remains on the Utah dead trees (Fig. 2E and Fig. 2F, respectively). Estimates were made of the percentage of the bark remaining on every standing tree on the 100 plots. Results computed for every fifth plot are shown in Table 5. According to Forest Service records made at the time of the infestation and observations during the course of the study, relatively little bark was removed

from the trees by woodpeckers in search of the bark-beetle larvae. Most of the bark remaining on the standing trees in Utah is still quite tight and for the most part unbroken except at season checks. In contrast, woodpeckers are quite common in Colorado and have removed considerable bark from the spruce there during the course of the recent infestation. The bark removal by these birds probably hastens somewhat the drying out of the trees and the rate at which season check takes place.

TABLE 5.—BARK RETENTION ON STANDING BEETLE KILLED SPRUCE IN UTAH

Estimated percentage of bark remaining	Trees	
	Number	Percentage
0–30	34	9
31–60	67	16
61–90	140	34
91 or over	177	42

Old Fires and Beetle Infestations in Colorado

Of value in the present study would be any information that might be available for comparative purposes on the length of time that Engelmann spruce remains standing and sound on old burns or areas of old beetle infestations in Colorado. No studies were made in burns mainly because they were difficult of access, because most of the dead timber had been removed in past years, or because, owing to the extreme age of the burns, practically all of the trees had fallen. General information, obtained mainly from Forest Service officials, indicates that a fair percentage of fire-killed spruce remains standing and sound up to 50 or 60 years and nearly all trees are down by about 70 years. On a large area of the Routt National Forest (in Colorado) burned over in 1879, the writer found in 1948, 69 years later, a few of the dead spruce still standing and sound.

The only area in Colorado on which information was obtained on an old beetle infestation in Engelmann spruce was on the Grand Mesa Forest. Sudworth (*11*), who visited the area in 1898, reported that between 25 and 40 percent of the spruce there was then dead and still standing, and advanced the theory that the timber died from a failure of long accustomed soil moisture. According to him, the trees succumbed 20 to 25 years prior to his visit (or between 1873 and 1878) and the dying appeared to have taken place within a period of five or six years. The death rate was remarkably uniform among the oldest and largest trees. A few of these old dead trees were still standing in the late '30's and early '40's, or nearly 70 years after their death, and a number of them that were cut then were all found to be free from decay. In a communication from N. D. Wygant[3] regarding this old dead spruce, he stated: "We are positive that the spruce beetle was the cause."

Applicability of Results of the Studies on Dixie Forest to White River Stands

The usefulness of conclusions reached from stand sampling on the Dixie in predicting the probable future course of losses of merchantability in the killed spruce on the White River National Forest depends on how comparable the conditions are in the two areas.

There are no weather records for the top of Boulder Mountain or anywhere near it, and the same applies to the White River Plateau in Colorado. Bowman (*1, p. 288*) estimates that the Aquarius Plateau, in which he includes Boulder Mountain, receives 24 to 30 inches of precipitation annually. According to Dorroh (*3*), the average annual precipitation on the White River Plateau is between 20 and 22 inches. There does not appear to be any great difference in climatic conditions between the two areas.

The elevations at which the dead Engelmann spruce occurs in Utah and on the White River Plateau are practically the same—i.e., mainly between about 9,500 and 11,000 feet. Soil on the former is, in general, shallower and more rocky than on the latter area. The main tree species and other common plants are the same on both areas. No common decay fungi have been observed in Colorado that are not present in Utah.

Both in the stands of the old beetle-killed spruce in Utah and those stands more recently killed in Colorado, there occur here and there old, decorticated and weathered, but sound, spruce snags practically devoid of limbs. These stand out in sharp contrast to the beetle-killed trees, which, in both localities, still retain a high percentage of their bark, twigs and limbs. Judging from the condition of these old weathered trees, they died at least 40 to 50 years ago, long before the beetles invaded the respective stands. Their presence is regarded as further evidence that the rate of deterioration and dropout of the beetle-killed spruce in Colorado will probably be similar to that in the Utah stands.

Because climatic conditions, plant species associated with the spruce, and decay fungi in the Utah area appear to be so similar to those of the attacked spruce stands on the White River National Forest in Colorado, it is expected that the rate of deterioration and fall of the trees on the latter forest will be similar to that which has occurred in Utah.

On the basis of the Utah studies and all the contributory information, it is therefore anticipated that a very high percentage of the beetle-killed spruce in Colorado will remain standing and in a sound condition for at least 20 years. Losses can be expected to be gradual over a considerably longer period. Even storms with winds of exceptional severity are not likely to cause heavy blowdowns in the dead timber except in very exposed situations. All evidence is to the effect that the time limit for the salvage of the dead Colorado spruce is not critical. The timber is suitable for corral poles, fence logs, mine props, house logs, lumber, and a good grade of paper pulp.

The rate of anticipated loss in this timber is very much slower than that found in insect-killed

[3] Forest entomologist, Bureau of Entomology and Plant Quarantine, U. S. Dept. of Agriculture. Letter dated January 28, 1949.

spruce in eastern North America, where trees on the Gaspé Peninsula killed by the eastern spruce beetle showed a loss from decay of 8.7 percent of the merchantable cubic-foot volume in 7 to 8 years (*9*), while that killed by sawfly lost 48.3 percent in the same period (*10*). The marked difference between the beetle-killed and the sawfly-killed spruce was attributed to the longer bark retention on the trees killed by the sawfly, permitting moisture retention that favored decay. On the eastern beetle-killed trees, much of the bark was removed by woodpeckers in search of the beetle larvae, allowing more rapid drying of the wood. Most fire-killed coniferous timber deteriorates rapidly and losses may be considerable in 3 to 5 years, depending on the species (*2, p. 439*).

Summary

Between 1942 and 1948, inclusive, bark beetles (*Dendroctonus engelmanni*) killed an estimated 4 billion board feet of Engelmann spruce in Colorado. About three-fourths of this loss has occurred on the White River National Forest and the remainder on six other national forests. The infestation has not yet ended.

The dead timber presents a major salvage problem. Deterioration losses to date have been negligible. However, information has been lacking on the length of time the beetle-killed trees would remain standing and in a sound condition. In an attempt to secure information, studies were conducted, mainly in Utah, where the spruce beetle killed a large stand about 25 years ago. The elevation, climate, and character of the stand in the Utah study area are so much like those in the Colorado stands that it is reasonable to expect the results of the Utah study to represent what can be expected to take place in Colorado.

Results of studies on 100 tenth-acre sample plots in Utah containing a total of 2,560 beetle-killed trees revealed that 84 percent of them were still standing and 16 percent had fallen. Basal and root rots have accounted for 77 percent of the dropout. Wind throw has not been a major factor in the fall of the spruce. Degree of slope, aspect, and character of the soil were not factors of significance in the rate of fall of the dead trees.

The trunks of the standing trees in Utah were found to be perfectly sound except for an occasional individual with basal sapwood decay that rarely extended more than a foot or two above ground level. Season check is the only defect of consequence and this is a factor only when the trees are cut for lumber. Checking occurs at a fairly rapid rate and starts in trees with green needles still attached.

Blue stain appears to have been caused by a single species of fungus carried into the trees by the beetles at the time of their attack. Only that portion of the bole involved in the attack by these insects shows evidence of any stain. Exceptionally few trees have been attacked by wood borers.

In standing trees that have been dead for three or more years, the moisture content of both heart and sapwood is below 22 percent, which is too low for decay. It is presumably the low temperatures in Engelmann spruce stands that delays decay until the wood becomes too dry for it to progress. A high percentage of the bark and branches still remains intact on the dead Utah spruce.

Rate of deterioration from decay of fallen trees is fairly rapid. Some of the fungi responsible for dropout of standing trees and decay of those fallen are listed. Salvage of the standing beetle-killed spruce in Utah, mainly for mine props and lumber, has been in progress for a number of years and is still continuing.

In Colorado a few trees of Engelmann spruce killed by fires and bark beetles many years ago remained standing and sound for about 70 years. A fair percentage of these trees were still standing at 74 years or more.

Based on all information obtained, it is anticipated that a high percentage of the beetle-killed trees in Colorado will remain standing and sound for at least 20 years. Losses can be expected to be gradual over a considerably longer period. Engelmann spruce killed by bark beetles remains sound for a very much longer period of time than eastern spruce killed by either bark beetles or sawflies.

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Use of Aerial Photographs on Large Forest Ownership[1]

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WITHIN RECENT YEARS, lumber companies having large forest townships in the southeast have become increasingly concerned with the management and productivity of their lands. Many such companies have had little information on forest inventory, no accurate maps, and few records of past cutting or other basic information that a forester could use for over-all management of the lands. Prior to the use of aerial photographs, a forester, in this position, would have needed several years of experience on the property and would have had to use expensive cruising and mapping methods. Now, with a set of good photographs, it is possible to map, inventory, and become sufficiently acquainted with a large property in a comparatively short time.

The Scotch Lumber Co., Inc. had a problem similar to that described above in the latter part of 1946. The ownership was slightly over 150,000 acres. A mill, with a daily capacity of approximately 100,000 board feet, was using timber cut primarily from these lands. At that time, our experience with photographs was very limited. The county in which most of the land was located had been photographed for the Agricultural Adjustment Administration in 1944. Luckily, these photographs were taken at the right season of year to give excellent timber contrast. Photographs of this county and older ones of our lands in adjacent counties were purchased. After some study and assistance from several men of the U. S. Forest Service,[2] we decided to map and inventory the entire property with our own personnel.

The first need was locating the lands on the photographs and preparing basic uncontrolled township maps for record purposes and general use. The land was located by finding enough section corners in the field for adequate control. Each section corner, as located, was pinpointed on the photograph. Other section corners were located from government survey plats, scale of individual photograph, and obvious land lines as seen from the photographs. Section and forty lines were drawn in. With the aid of a pocket stereoscope, streams and roads, not easily discernable, were traced with a grease pencil for each section. Because of the variation in scale of the photographs, usually from one flight line to another, the section corners of an entire township were first assimulated under a tracing. The individual photographs were then placed under the tracing and all features were transferred to it. The uncontrolled township maps were generally accurate within themselves but would not necessarily conform to one another. Film negatives were prepared from the tracings and prints were made as needed. No special mapping equipment was purchased.

With the completion of the mapping project, timber inventory plans were made. This was our first experience. In retrospect, we can see where much time could have been saved in inventory procedures, which were devised overcautiously. Six timber types were recognized: old growth pine, second growth pine, pine-hardwood, upland hardwood, bottomland hardwood, and scrub oak. Timber size was classified as seedling and sapling, pulp, small sawtimber, and large sawtimber. Small and large sawtimber were divided only in the second growth pine type. Tree height was recognized from 1 to 3 logs and 4 or more logs in old growth pine and large sawtimber in the second growth pine types. Five crown closures with a 20 percent spread between each were used. Open land and land occupied by power lines, roads, and water were segregated. With the timber thus classified eighty-one separate type and condition classes were formulated. At that time, it was believed that all these classifications were necessary to keep variation within a class to a minimum. Fewer classes could have been used with the same degree of accuracy.

By stereoscopic study and field examination, the entire property was typed by condition classes, with the boundary outlines shown on the photographs. These boundaries were transferred to tracing paper where each condition class was numbered for a permanent record.

Acreage determination of each condition class was made by quarter-section, section, township, and the entire property. Several acreage grids for fitting the scale of the individual photographs were used in making these determinations.

The volume estimate of any one condition class was not too important since we were primarily interested in the accuracy of the overall estimate. Sufficients plots, however, were taken in important classes to give a good degree of accuracy.

Cruise lines were established by pinpointing a starting place on the photograph that could be found easily in the field. The distance to the first plot, in a cardinal direction, was chosen at random. The plot location was then pinpointed. On the back of the photograph, the cruise line, plot, and condition class number were noted. Succeeding plots were located in a similar manner. The number of chains between plots varied from three to ten. Care was taken to sample each condition class on all parts of the property.

Oblique triangular plots were used on the cruise. This type of plot was felt necessary to eliminate

[1]Paper given at a meeting of the Forestry Section, Association of Southern Agricultural Workers, Biloxi, Miss., Feb. 9, 1950.

[2]Acknowledgement is made to E. T. Hawes, D. J. Morris, and Lewis Grosenbaugh of the U. S. Forest Service for assistance in photo interpretation and statistical analysis.

error in tallying trees on or near the plot edge and because three local men with no previous cruising experience, other than a week of intensive training, were used. All trees were calipered; therefore, our main chance of error was in height estimates. The men were trained on this phase particularly. They were also trained to estimate average form class by the classifications of poor, medium, high, and very high.

Equipment for the three-man crew consisted of a two-chain tape, pocket compass, staff compass, caliper, tally board, and lumber crayon. The procedure for setting up plots was as follows: The cruiser established the base of the plot by setting the staff compass perpendicular to the direction of the cruise line. The remaining two men pulled the tape one chain on each side of the staff. The tape was then considered as the base line. One man, with a homemade device for triangulating the sides, set up his instrument at one end of the tape and sighted along the base, then turned the instrument to a set degree for the side. He then sighted along this line and blazed the side for the necessary distance to intersect the other side. The same procedure was repeated for the other side of the plot. In this way, all trees within the plot were bounded on two sides with a blazed line and the two chain tape along the base. The cruiser, in the meantime, began calipering each tree towards the side first established. Each tree as measured was marked with lumber crayon to avoid duplication. The third man was the tallyman.

For each plot the following information was gathered: species—pine, gum and poplar, oak, and other hardwood; sizes—pulp and sawtimber; sapling and seedling count; mortality within the past year; growth information; cull percent for pine and hardwood; average log grade for pine and hardwood; and the average form class.

Slightly over 5,000 plots were used for all condition classes. This number of plots represents heavy intensity of volume sampling on 150,000 acres. However, since this was the first timber inventory of the property in many years and, too, the company planned to use the timber inventory estimates for other business reasons than forest management, such heavy sampling was believed necessary.

There are always errors of misclassification in photo interpretations. Such errors can be minimized by careful stereoscopic study and field examination. Including errors of misclassification, accuracies of 4.1 percent of pine sawtimber, 5.4 percent of hardwood sawtimber, and 2.0 percent for pine pulpwood were attained.

Aside from their use for mapping and inventorying, aerial photographs are of greater benefit in the conduct of daily business. They are probably the greatest time saving device a forester on a large property can possess. Without photographs, one can spend a great deal of time showing personnel where to go and what to do. With photographs, timber markers, surveyors, and other personnel can be dispatched in a short while with a clear conception of the day's job. Little or no assistance is needed in learning the property. Land corners, roads, timber, and other features can be located without difficulty. Working daily with photographs gives the user a mental picture of the timber and terrain that couldn't possibly be acquired without long experience on the property. Errors can be readily discovered in land descriptions. Logging operations, planting, road construction, fire suppression and investigation, and timber stand improvement work can be planned with a great deal more efficiency and less time. Aerial photographs serve as a permanent record of timber conditions at the time of flight and can be compared with subsequent flights.

Usually, photographs made for general government use are not very useful for timber purposes. It is well to consider having the lands photographed for forestry purposes if government photographs are out-of-date or otherwise unsuitable.

Photographs have eliminated the indispensable man who knows a large property from long experience. Now a person knowing something about photographs can take over the management of a large property within a short time if he is experienced in timber management and has a good set of photographs.

Notes

Federal Aid for Sport Fishing

On August 9, 1950, President Truman signed the Dingell-Johnson Federal Aid to Fish Restoration Act, a measure designed to do for the nation's fifteen million sport fishermen what the Pittman-Robertson Federal Aid to Wildlife Restoration Act has done so outstandingly for nearly thirteen million licensed hunters. Federal responsibilities under the new law will be administered by the Fish and Wildlife Service through its Federal Aid Branch. Funds to finance the 75 percent federal share of project costs on this fish restoration program will come from receipts from the 10 percent excise tax on rods, reels, creels, and artificial lures, baits, and flies. It is estimated that the tax on these items brings in about three million dollars annually. The first appropriation to finance this new law is authorized for the year beginning July 1, 1951.

Apportionments of appropriated funds to the individual states will be based on the ratio of the area (including coastal and Great Lakes waters) and the number of paid angling license holders in each of them, to like totals for all the states. Furthermore, no state may receive more than five nor less than one percent of the total allotted to the entire group. This will assure several small states of enough Dingell-Johnson Act revenue to finance substantial fish restoration measures. The act also authorizes maximum annual allotments of $75,000 to Alaska, $25,000 to Hawaii, and $10,000 each to Puerto Rico and the Virgin Islands.

In outlining approvable activities, the law emphasizes fact finding. This is a work phase that many of the states are most anxious to stress. As was the case with the artificial propagation of game birds prior to initiation of field study projects under the Pittman-Robertson Act, fish rearing be[illegible]s in the hatcheries are far ahead of knowledge of how fish can be most effectively managed in their greatly varied aquatic pastures. The other two lines of approvable work are concerned with acquisition of lands and waters and their development. Land buying will undoubtedly include purchase of public fishing waters, access to such waters, and lands on which water can be impounded to create new fishing opportunities.

In the developmental field it is anticipated that in addition to impounding water the states will stress stream and lake improvement work. Tied in with such improvement measures will be manipulations of fish populations by partial poisoning, stocking, water-level shifting, and harvesting controls.

An interesting feature of this new restoration activity is that in developing public fishing waters there are numerous opportunities to finance work beneficial to both fish and wildlife in single areas by having Pittman-Robertson and Dingell-Johnson money defray costs of their proportionate share of the betterments. Consequently, it is expected that numerous projects embodying both activities will come from this prototype of the Federal Aid to Wildlife Restoration program. To illustrate, big game winter range acquisition units often include excellent fishing waters, the worth of which must be counted in the overall costs. With both fish and wildlife funds available to the states, the respective shares of the two can be determined and levied. Many impoundments are beneficial to fish as well as waterfowl and other animals. Here again, the assuming of fish and wildlife costs in proportion to benefits to be derived by each will assure construction that could not be otherwise financed.

As is the case on the Pittman-Robertson program, the states through their fish and game departments will select suitable projects and perform the work on them with their own personnel. All lands acquired, structures erected, and equipment purchased will become state property. Responsibilities of the Fish and Wildlife Service will be confined to determining whether projects are substantial in character and design within the meaning of the law, whether the estimated costs are reasonable, and whether the work has been properly performed before clearing state reimbursement claims for the 75 percent federal share of project expenditures.

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Annual Meeting Soil Conservation Society of America

The fifth annual meeting of the Soil Conservation Society of America was held at Hotel Statler, Detroit, on October 26-27-28, 1950. Attendance exceeded five hundred including representation from thirty-six of this society's forty-nine chapters.

The theme of the meeting was water and humus. Thirty talks and papers were presented during the two and a half days of scheduled programs.

Any attempt to report on subject matter presented, that would be of particular interest to members of the Society of American Foresters, would undoubtedly be incomplete. A number of papers presented newly acquired data contributing to our knowledge of conservation techniques. There were several papers, however, that had a particular bearing on the interests of foresters and pertained to the advancement of conservation. These would include: Morris L. Cooke's paper on "Water Resources" which broadened its subject title to include application of conservation programs through social and political forces. Cook's pa-

per, and that of Carl C. Taylor who talked on "Conservation A Social and Moral Problem," raised many questions on the *how* of securing public and landowner response to action. (This reporter wonders whether foresters have not become too self-sufficient and, in so doing, developed an ego that precludes accepting the fact that sociologists and others can contribute to our problems of securing acceptable public concern and action.)

Dr. Irving Langmuir's talks on "Possibilities of Rainfall Control Over Wide Areas by Cloud Seeding" and "Discussion of Rainfall Control Possibilities," were the most startling in their implications and aroused the greatest "cloakroom comment." Control of climate may not be beyond possibility with all its potentials and effects on watershed management or shelterbelt plantings.

There were many members of the Society of American Foresters present. Fellow S. T. Dana introduced Charles F. Kettering who gave a luncheon talk on "Looking Ahead." Kettering continues his work on chlorophyll and was very optimistic of the future and not particularly concerned for the need of conserving our natural resources. Technology and mining the ocean are his "lodestars."

Dana commented on the University of Michigan's newly organized School of Natural Resources. P. A. Herbert outlined developments of Michigan State's new School of Conservation. Paul B. Sears presented a paper on Yale University's "The New School of Conservation."

The growth of the Soil Conservation Society of America has been remarkable. Beginning with a handful of members in 1941 and not expanding because of war conditions, until 1946 when the first annual meeting was held, it now has a membership exceeding 4100 in the United States and 38 foreign countries.

President-elect is a forester, Morris Fonda. Others officers for 1951 are: First Vice-President, Austin L. Patrick; Second Vice-President, George M. Browning; Treasurer, Warren Huff; Secretary, Alvin C. Watson. In addition to these officers there are nine other members composing a council. Society officers and members of the council represent eight allied professions thus welded to become one as conservationists so as to promote and advance all phases of the science of conservation of soil and water resources.

The Society's 1951 annual meeting will be held in Memphis, Tennessee, November 12-13-14.

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A Platform and Preliminary Plan of Action for the Scientific Use and Development of Natural Resources

The Natural Resources Council of America, of which the Society of American Foresters is a member, has attempted to define the broad principles governing the sound management and wise utilization of land, water, and the living resources. One purpose of attempting such a definition is to inform the public as to the basic reasons, as well as needs, for a national land and water policy.

The following platform and preliminary plan of action are not the product of any one person or organization, but represent the combined opinion of numerous individuals who helped formulate the proposals.

Changes and modifications will doubtless be made by individual organizations in adopting such a policy statement for their own use or guidance. The important thing seems to be to get the organizations — professional, scientific, and educational — that are interested in promoting the conservation of resources to agree on a few basic tenents so that there may be general agreement on essentials.

Readers of the following statement are reminded that the suggested "action" to be taken under each "principle" is merely one of many that may be taken. This statement is published for information only. It has not been approved by the Council of the Society.

There is today a growing awareness of the fact that land, water, the living resources, and man are intimately related. Resource management must be considered not only in its separate categories, but in its entirety. It is time for the adoption of a national policy on natural resources. Agreement on such an objective will lend force to the successful prosecution of a broad resource-use program, and strengthen the support given to each resource. With these conditions in mind, a majority of the member organizations of the Natural Resources Council of America adopted the following platform and preliminary plan of action on October 2, 1950.

A Land and Water Policy

1. *Principle.* Adoption of a national policy by the Congress of the United States to secure in the public interest the maximum benefits from the nation's land, water, and related natural resources.

Action. Cooperate in the preparation of a comprehensive statement and policy designed to insure the permanent wise use of land, water, and related resources and the preservation of natural park and wilderness areas.

An Appraisal

2. *Principle.* Adequate inventory of the land and water resources of the nation to determine their condition, productivity, and potential use in relation to a priority of human needs.

Action. Support current inventories of all land, forest, water, range, and wildlife resources as the proper guide to the utilization and treatment of these resources; and develop other inventories where need is demonstrated in the public interest.

A Goal

3. *Principle.* Achieve unified scientific management and perpetuation of land, water, and the living resources in the widest public interest.

Action. Support the rapid development and application of a comprehensive scientific conservation plan for every unit of the nation's land and water; such plans to be appropriately coordinated with watershed protection and other programs designed for wise resource use and perpetuation.

A Method

4. *Principle.* Strengthen individual and group responsibility and participation in the planning and effectuating of conservation activities.

Action. Give continuous support to sound conservation programs on all public and private lands, and as a primary step, encourage the organization and development of soil conservation districts throughout the nation and urge widespread assistance to such districts.

A Motive Power

5. *Principle.* Economic, social, and cultural stability of the nation depends on scientific management and use of natural resources in the public interest.

Action. Promote educational programs designed to develop and perpetuate the concept of conservation to the end that all may share in putting them into effect and in enjoying the resulting benefits.

Grassland Monuments Proposed

In December 1948 the Natural Resources Council of America, of which the Society of American Foresters is a member, held a joint meeting to discuss problems of natural resource conservation with the Secretary of Agriculture and his official family.

One proposal which grew out of this meeting was the appointment of an Exploratory Committee on Grassland Monuments within the Department. The purpose of the committee was to develop information which might be mutually helpful to the Council and the Department in obtaining the creation of a system of representative grassland study areas.

Because many members of the Society of American Foresters are interested in range ecology and range research, the report of this committee is published herewith for their information.

As the Natural Resources Council is a service agency for some 35 member organizations, it cannot on its own account initiate direct action in support of the report's recommendations. However, the report will be discussed at the Council's next meeting in Milwaukee in March (at the time of the North American Wildlife Conference) to determine what actions may be taken by member organizations to carry out the recommendations.

HENRY CLEPPER, *Chairman,*
Natural Resources Council.

Report by the Exploratory Committee on Grassland Monuments

The Department of Agriculture Exploratory Committee on Grassland Monuments has given careful consideration to the advisability of the establishment of natural grassland areas. In making the survey underlying the recommendations which follow, its members have conferred with representatives of the Natural Resources Council, the Grassland Foundation, land grant colleges, and other state and federal agencies. Information was requested from persons and organizations interested in preservation of natural grassland areas for research and related purposes. All of this information has already been carefully digested, evaluated, and used as a basis for the following recommendations:

1. The establishment of publicly owned natural grassland areas to assure preservation of a representative area typical of each of the major grassland types of the nation is important and urgent. The Department of Agriculture should give support to the establishment, protection, preservation, and study of such areas.

2. The primary purpose of such areas should be the preservation and study of natural grassland areas. Secondary objectives should include consideration of education, recreation, inspiration, and other related values.

3. In carrying out the primary purpose — the preservation of the grassland aspect — consideration should be given to the maintenance of certain species of the original natural fauna. In order to assure preservation of the grassland aspect, including the natural recovery of deteriorated areas, unrestricted development or increase of certain species of the natural fauna may require control.

4. There are six major grassland types that should be considered for representation in the establishment of such natural grassland areas. These types are (1) the tall grass prairie, extending from eastern North Dakota southward to Oklahoma and eastward into Illinois; (2) the mixed prairie extending from North Dakota and eastern Montana southward to northeastern New Mexico and the panhandle of Texas; (3) the coastal prairie, especially of southeastern Texas and south Florida; (4) the desert plains grassland of southwest Texas, New Mexico, and Arizona; (5) the Palouse prairie in Idaho, Oregon, and Washington; and (6) the Pacific Prairie of the San Joaquin and Sacramento Valleys in California.

5. In each of these major natural grassland types, it would be desirable to establish, if suitable reservations are not already available, one area of 20,000 acres or more.

6. In addition to large grassland areas in each of these six major natural grassland types, additional small natural areas varying in size from a few hundred to several thousand acres each doubtless would be advisable to represent localized phases or subtypes of the major grassland types. Such small areas might be set aside within experimental ranges already available, national or state parks, or other suitable reservations or be established as separate units.

7. Among specific purposes which

justify establishment are the following:

Research. In research it would be advisable to have a group specifically assigned to each of the major natural areas to make an initial survey of the situation relating to vegetation, natural fauna, existing environmental conditions due to past use, etc., and to record periodically changes occurring naturally, including study of natural biotic factors, the interrelationships between reasonable numbers of the original fauna and the flora, the natural recovery of deteriorated areas, the life histories and growth habits of individual plants and animals, and the whole ecological background of natural plant development and restoration in its relation to its component parts and the basic soil that maintains the vegetation. In addition, other researchers should have access to the area for supplemental studies.

Check areas as guides to land use. A highly important reason for preserving natural grassland areas is that they are valuable as ecological standards. This is a practical value, particularly applicable to conservation and land use programs. Natural areas are unique for what they can tell us of the potentialities of land for use. Undisturbed natural areas are few in most parts of the United States. Yet selected areas, properly situated and of appropriate size, protected and set aside now, could in time teach us a great deal that would be useful. Such knowledge would be of practical value not only in range management, but in many other fields of resource use as well. Thus, along with its other values the establishment of natural grassland areas can serve a utilitarian land use purpose that should be given conspicuous attention.

Education. While it may be advisable to restrict carefully ingress to the greater part of each major natural area, certain parts should be dedicated to and made accessible to those who come to observe or otherwise use for educational purposes the parts of the natural areas dedicated to that purpose.

Recreation. Closely related is recreation, and it may be necessary to dedicate limited portions of the natural areas to recreational development to facilitate the use and enjoyment of the natural areas, or those parts which can be made readily accessible to the general public.

8. There are very few large areas in the main grassland types that are already available which might serve this purpose. Among those to be considered, however, are the Theodore Roosevelt National Memorial Park in western North Dakota, the Badlands Monument in South Dakota, the Wichita Mountain Wildlife Refuge in Oklahoma, and the Everglades National Park in southern Florida. Consideration should be given as to whether the present purpose of these areas could be broadened to serve the purpose designed for the natural areas herein under consideration.

9. If it is found that these areas already mentioned are not suitable for the purpose of preservation of natural areas, then it would seem necessary for the federal government or private organizations which might be interested in the establishment of such areas also to purchase the necessary lands now in private ownership of the grassland types they represent in order to obtain suitable natural grassland areas, or even to expand any that are now available.

10. To assure effective continuity in the ownership, preservation and research, and to coordinate the several areas, jurisdiction and administration of the six major units should be by the federal government. The National Park Service of the Department of the Interior may be the agency which can satisfactorily assume responsibility for their acquisition, custody, maintenance, and administration. In view of the responsibilities of the Department of Agriculture for research in the field of agriculture and of the Department of the Interior for research in the field of wildlife, the two departments should participate jointly in assuming responsibilities for such research activities as are undertaken, in accordance with their customary procedures. Smaller units within existing federal reservations would presumably be administered by the agency administering the larger unit of which the natural grassland area is a part. Other smaller areas would logically be owned and administered by states and local units of government.

11. There does not appear to be any appropriate legislation to meet the specific need with regard to the large areas as outlined above. If the proposal is approved, it would doubtless be advisable to prepare a suitable bill to present to Congress embodying the essentials, authorizing the necessary funds for acquisition, administration and research, and setting forth the necessary restrictions on the type of activities to be carried out within the natural area as proposed.

O. S. AAMODT, *Chairman,*
Agricultural Research Administration.
W. R. CHAPLINE,
U. S. Forest Service.
F. G. RENNER,
Soil Conservation Service.

Reviews

Log Defects in Southern Hardwoods.

By C. R. Lockard, J. A. Putnam, and R. D. Carpenter. 37 pp. Illus. Agriculture Handbook No. 4. U. S. Govt. Print. Office, Washington, D. C. 1950. 25 cents.

The authors of this U. S. D. A. publication have compiled information on a subject which has always been quite complex and seemed to defy an organized pattern. Classification and scaling of hardwood logs with a marked degree of accuracy has always been a task for a select few whose long experience had allowed them to recognize defect in its proper perspective quickly as well as proportionately. These same people would have much trouble explaining or teaching this ability to anyone else.

In standing timber, the task becomes even more difficult unless some clear analytical method of search can be applied to the trees. The authors have shown in their classifications the positive need for the grouping of defects by log use. This point is emphasized, and rightfully so, as it is impossible to classify logs properly and bring their respective defects into the proper perspective unless the use to which the log or tree will be put is known.

Observation only of the pictures and the appendix will be time well spent and extremely informative. In a subject as difficult to break down as is this one, pictures of the type found in the publication prove further that visual education will teach or bring out points of information quicker, more clearly, and more definately than any other way.

With the supply of high grade hardwood timber in the South rapidly diminishing, the importance of the proper channeling of logs to markets where they will be of most value is magnified. The job of assisting industry in these classifications falls, in many cases, on foresters. The need for accepted specifications has long been felt, but this is the first well defined step toward that goal.

In evaluating and applying the information to standing timber the forester has a more difficult job. Undoubtedly a careful study of the booklet, particularly as to its use along with experience will make for improved timber appraisals.

Authors Lockard, Putnam, and Carpenter have shown that it is possible to take a complex subject and reduce it to well organized, every day language for practical use.

WILLIAM F. MILLIKEN,
Consulting Forester,
Williston, S. C.

Small Town Renaissance.

By Richard Waverly Poston. 231 pp., Harper & Brothers, New York. 1950. $3.

Conservationists have long stressed the close relation between natural resources and rural welfare. In fact many conservationists pride themselves on being not only biological scientists — foresters, range specialists, ecologists, entomologists, pathologists, etc. — but also social scientists, sociologists, and economists. Because of this breadth of interest conservationists frequently become involved in community affairs and problems relating to community development. Those who have such a leaning will find Richard Poston's *Small Town Renaissance* refreshing, stimulating, and just good reading.

It is the story of the Montana Study, a project conceived by Ernest O. Melby, a former chancellor of the Montana State University and financed through a grant from the Rockefeller Foundation, Humanities Division. The study, organized in 1944 and terminated in 1947, set out to make the university of greater service to rural people, to find ways and means to stabilize the family and small community, to improve the standards of living, and to raise the spiritual standard of living by making small communities more interesting places in which to live.

In a state where for more than two decades rural population has been declining and from which many high school and college graduates have been going to the big cities outside the state for employment, the Montana Study suggested one way to reverse these trends. Unfortunately, the study encountered much criticism, strong political opposition, and according to Poston "fell into the ridiculous position of being called communist inspired." Whatever may have been the shortcomings of the Montana Study, the story of *Small Town Renaissance* is one with which community-minded conservationists should become acquainted.

Foresters, especially, will find Richard Poston's book of interest and use in community work. Far more significant than the vicissitudes and tribulations of the Montana Study are the case histories of community projects carried on during the three years the study operated. Two of these case histories relate to what the study did in Libby and Darby, small towns in the western part of the state that are dependent upon timber resources. The community problems which result from timber depletion were the subject of study in both of these towns. Poston forcefully, perhaps at times too dramatically, tells the history of Libby and Darby, emphasizing why an effort was needed to revitalize the economy and social institutions.

In Libby, for example, the author points out how the number of large sawmills dropped from five to one, leaving ghost towns in their wake, and how even the last mill may be threatened in a few years unless public and private forest lands are managed cooperatively to sustain forest production. Much of the story of the proposal for establishing a sustained yield unit around Libby is recited. Reference is made to the monopoly aspects of such forest units and what people

thought this might mean to the future of their town. The part taken by the Montana Study in organizing study groups, encouraging active participation by industry, labor, and others and the community support which resulted for a sustained yield unit all emphasize the problem of how to get positive constructive community action.

Likewise, the story of Darby is well told. Although over-dramatic in places, the story is basically correct and suggestive of ways and means of solving community problems in other areas. In the appendix of the book is an outline of a study group project which has many ideas on how to get people to think and act to overcome problems at the local level.

Although some may condemn the work on the Montana Study, there are few who can question the need for emphasis on making rural communities more livable and there are many who will benefit by becoming acquainted with the techniques tried by the Montana Study.

M. B. DICKERMAN,
Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Mont.

You Too Can Grow a Redwood Tree!

By W. W. Anderson. 16 pp. Illus., maps. Published by the Author, Kentfield, California. 1949. 50 cents.

The author of this very attractive and informative 16-page pamphlet is a redwood enthusiast who wants to help others to know this tree better and get enjoyment from knowing it. He goes several steps farther. He has made the entire subfamily *Taxodiaceae* a special hobby, and he has formed what he calls the Rare Plant Club. The purpose of this non-profit club is to make America more beautiful; to preserve rare plants and trees in natural wilderness areas; to distribute native plants and import desirable ones from other countries; to conduct research on the needs of these plants; to propagate and hybridize prospective ornamental trees and smaller plants and to promote a high standard of business ethics among plant producers. The pamphlet devotes two of its pages to the promotion of this club.

Mr. Anderson is an advertising executive in San Francisco, but devotes much of his considerable energy to his redwood and Rare Plant Club interests. His booklet is divided into parts under the following heads: Two Types of Sequoias or Redwoods; Which Sequoia Should You Choose?; Adjusting Redwoods to your Climate; Planting Out Your Redwood; and others.

Being an amateur in the tree field he has fallen into some errors but, being a natural student, he has recognized them and is planning to produce an improved edition of his pamphlet.

Since the discovery of a living forest of *Metasequoia* in China and its wide publicity under the name of Dawn Redwood, and the introduction of seeds, several growers are offering potted trees for sale. He also refers to *Taxodium distichum* as American redwood. The reviewer is moved to remark that the confusion among common names will get worse rather than better if more liberties are taken with well established vernacular names. If redwood is the layman's *Sequoia*, like oak is for Quercus, we should not use such names for other genera.

Although the author deserves credit for his enthusiastic interest, readers of his booklet may run into discouragement if they take his recommendations too literally, particularly the one applying to parts of the United States in which Sequoia will grow. His maps showing where each Sequoia may find a suitable climate cover too much territory. However, he protects himself with the statement "Local conditions in some places within this zone may or may not be suited to this Sequoia." Nevertheless, by dint of persevering correspondence, he has received many reports of specimens of *S. gigantea* growing as far north as New England and of *S. sempervirens* as far north as Virginia. Some of these localities had not heretofore been publicized.

EMANUEL FRITZ,
University of California, Berkeley.

Contents and Title Page Bound in Journal

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Current Literature

Compiled by MARTHA MUELLER, *Librarian, The New York State College of Forestry*

Range Management Section Compiled by FRANCES FLICK, *Library, U. S. Department of Agriculture*

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Society Affairs

Compiled by ROBERT D. HOSTETTER, *Assistant Executive Secretary*

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Section Delegates Advise Council on Society Policies

What role should the Council and the Society play in formulating and establishing forestry policies? On what specific current national issues should the Society seek facts and establish policies? Once policies are enunciated, how best can the Society, and particularly the Sections, implement them? What is the one nation-wide project that the Society, through its Sections, can most effectively pursue during 1951?

Answers to those questions and others will be offered by the official delegates of the 21 Sections when they meet jointly with the Council on Wednesday afternoon, December 13, in a preliminary session of the Golden Anniversary Meeting of the Society.

In addition to discussions regarding appropriate Society action on important forestry issues, the delegates will enter a discussion of effective ways to acquaint non-members with the objectives, policies, and programs of the Society. This discussion will be led by a panel of experts from several Sections. Council Member R. E. McArdle, chairman of the Committee on Elections to Membership, will act as moderator.

In making the final selection of discussion topics from those suggested earlier by the Sections, President Charles F. Evans emphasized the fact that the primary purposes for inaugurating the joint meetings of the Council and Section delegates were to afford the Council the benefit of the viewpoints of the various Sections and to allow the Section delegates to share experiences in effective Section functioning. Mr. Evans will preside at the Council-Section Delegate meeting which is to be held from 2:00 p.m. to 5:00 p.m. on Wednesday, December 13.

A preliminary meeting of the Section delegates will be held at 10:30 a.m. on the same day. The Council will not be present during the morning session. Robert D. Hostetter, assistant executive secretary, will preside. Administrative problems affecting the working relationships of the Sections, Chapters, and the Society office will be considered. Among these will be discussions of the effect of the November referendum on membership requirements, possible improvements in the Section Manual and in Chapter operation, editing Section newsletters, and other topics suggested by the delegates.

The Council will meet in executive session on Wednesday morning, December 13, and at subsequent times as required.

Time has been allotted during the Society Affairs sessions on Thursday afternoon, December 14, for general discussions from the floor on any appropriate subjects.

Jackson Group Publicizes Anniversary

The Golden Anniversary of the founding of the Society was commemorated on October 12 during the Mississippi State Fair when the above unit participated in a two-mile-long Forestry Parade. Members of the Jackson Chapter of the Gulf States Section riding in the station wagon included J. Walter Myers, Section Secretary-Treasurer; John W. Squires, former Section Chairman; D. E. Sanderborn, Monty Payne, and Percy Howell. The Forestry Parade, which was held in Jackson, Miss., included floats and bands and was witnessed by 15 or 20 thousand people.

Meeting Committees Make Final Plans

At a meeting called on October 13 by Chairman George R. Phillips, the Golden Anniversary Meeting committee wound up final plans for what promises to be the largest Society meeting ever held. Advance requests for hotel room reservations indicate that attendance will exceed 1,000 members and guests.

Programs of the ten Divisions are now final. All day sessions have been scheduled by the Divisions of Education, Forest Recreation, Private Forestry, Public Relations, Range Management, Silviculture, and Watershed Management. Those which will have half-day sessions are the Divisions of Forest Economics, Forest Products, and Forest Wildlife Management. The Division of Education will meet on Wednesday, December 13, and the Divisions of Public Relations and Silviculture will have preliminary sessions that evening. All other Division meetings will be on Friday, December 15, preceding the dinner dance.

The three host Sections—Washington, Allegheny, and Appalachian—have invited all members and guests to attend the dance which follows the banquet program. Tickets for the banquet should be purchased at the time of registration, but no tickets are required for the informal dance which is presented by the host Sections.

Golden Anniversary favors, which are both attractive and useful, are also being provided by the host Sections. The favors committee was headed by D. E. Hess.

A new feature of the annual meeting will be the issuance of a special Golden Anniversary Meeting newspaper to those in attendance. Its publication is being arranged by Charles W. Mattison, chairman of the Publicity Committee. A roster of registrants will also be issued at the meeting this year.

Decorations for the banquet are being provided by the Dinner-Dance Committee of which J. H. Johnson is chairman. Maryland holly will be the principal decorative material used.

Indications are that many members' wives are planning to attend the meeting. Special activities arranged for them by a committee headed by Mrs. E. N. Munns are a tea at the Pinchot home on December 14 and a tour to Mount Vernon on December 15.

H. R. Josephson, chairman of the Information and Welcome Committee, has provided informational material regarding points of interest in Washington. His committee will also assist in directing members to meeting rooms so that all sessions can begin promptly.

For the first time a Division officer's breakfast has been arranged to permit the officers of the subject Divisions to meet with the Council. At this dutch breakfast, scheduled for 8:00 a.m. on December 14, President Charles F. Evans will bestow his authority upon the Division chairmen to conduct the individual sessions. Procedural questions can also be discussed at the same time.

Following the final general session on Saturday morning, December 16, the Council of Forestry School Executives will meet.

The report of the Golden Anniversary Meeting will appear in the February 1951 JOURNAL OF FORESTRY.

Puget Sound Section Studys Marketing

Seattle, Wash., October 1950. The foresters of the northwest corner of the country are turning to the marketing of forest products as their main road of progress for the year ahead.

Such was the No. 1 announcement of newly installed Chairman William A. Tinney at the first Puget Sound Section meeting since the election of officers to serve until June 30, 1951.

"There is no subject to which professional foresters are giving more study and discussion than that of the marketing of forest products," Tinney stated. "The public is vitally interested too. A recent issue of *Collier's* featured an article entitled 'Money Grows on Trees' and it demonstrated how reforestation programs are developing all over the land because tree growing is now good business. How can foresters help to make it better business in this region, at the same time helping to reassure retail lumber dealers and other merchandisers of wood on future supply? This is the forestry question of the hour."

Tinney, long a farm forestry specialist, and now forester for the Conservation Committee of the Pacific Northwest Forest Industries, succeeds Vincent Bousquet, Centralia, as Section chairman.

New vice chairman is Norman Worthington, head of the U. S. Forest Service Pacific Northwest Forest and Range Experiment Station at Olympia, and the secretary-treasurer for the year ahead is John Allen, Seattle, of the Forest Products Institute of Washington State and author of the standard handbook on marketing the products of Washington farmers' woodlots.

Bousquet Gives Gavel to Tinney

Left to right: Tom Hopkins, Olympia, assistant to state forester and retiring vice chairman; Vincent Bousquet, retiring chairman of Puget Sound Section, Society of American Foresters, hands the gavel to William A. Tinney, newly installed chairman. Norman Worthington, standing, new vice chairman, and John Allen, 1951 secretary.

Editor's Note: The accompanying item and photograph were released to forestry and lumber trade journals by the Puget Sound Section following its October 1950 meeting. As well as providing Society members with a report of the meeting, it is published here as an example of a desirable manner in which to make known the activities of the Society's Sections and Chapters.

Gulf States Section Contacts Non-Members

William M. Palmer, Jr., membership chairman of the Gulf States Section, reports that all foresters in the three states which comprise the Section — Mississippi, Louisiana, and Texas — are now listed in state directories. Non-members of the Society as well as members are included.

To contact eligible non-members regarding the desirability of their membership in the Society, Mr. Palmer has appointed a Society membership chairman in each state: Mississippi—Mike O. Stark; Louisiana—Charles W. Robertson; and Texas—Don Young.

Mr. Stark divided the state of Mississippi into nine districts with a chairman for each district. The district chairmen coordinate the work of chairmen located in each county in the state in personally contacting all eligible non-member foresters.

The executive committee of the Gulf States Section established a goal of 100 new members to be achieved during the year preceding May 1, 1951.

While encouraging his assistants to invite eligible foresters to apply for membership, Mr. Palmer pointed out, "We should ever keep in mind that ours is a professional society and I believe that we should keep it such. That places something of a burden on us to be careful in our endorsements and to urge all others in a position to endorse applicants to feel sure that the applicant meets the requirements."

Queries and Quotes

"Where self-interest is placed above service, reputation suffers."—H.H.C.

"I intend to keep contacting and writing non-member foresters until they join."—M.O.S.

"The good work which the Society, led by hard working officers, has been doing these many years deserves some advertising."—V.M.B.

Coming Events

The Southeastern Section will meet on January 12 and 13, 1951 at Albany, Ga.

Monroe, La. has been selected as the site of the 1951 meeting of the Gulf States Section. The exact dates have not yet been set; however, the meeting is usually in May.

Candidates for Membership

Candidates for membership whose applications were received in the Society office prior to November 1, 1950 are listed below. Names, positions, addresses, and education are given.

Action regarding the eligibility of these candidates will be taken by the Council as of January 1, 1951. Comments, protests, or important information regarding the qualifications for membership of candidates listed are invited from present voting members. All such communications are kept strictly confidential, being used only by the Council in taking final action on applications. Correspondence should be received in the Society office prior to January 1, 1951.

The names of those candidates who are elected will be published in the February 1951 JOURNAL OF FORESTRY. The names of those who signify their acceptances of election will be published in subsequent issues of the JOURNAL.

Allegheny Section

Junior Grade

Corley, J. C., Box 501, Philippi, W. Va.; W. Va. Univ., B.S.F., 1950.

Judd, H. F., Dist. Highway Forester, Pa. Dept. of Highways, Pittsburgh, Pa.; Pa. State, B.S.F., 1937.

Keller, W. C., Rgr., Standing Stone Exp. Forest, Huntingdon, Pa.; Pa. State, B.S.F., 1948.

Parker, R. W., Research Asst., State of W. Va., Morgantown, W. Va.; W. Va. Univ., B.S.F., 1950.

Appalachian Section

Junior Grade

Cavannaugh, M. J., 303 Bratton St., Winnsboro, S. C.; N. C. State, B.S.F., 1950.

Ince, G. A., 2232 Cranford Rd., Durham, N. C.; Colo. A & M., B.S.F., 1950.

Millers, A. W., 705 1st Ave., Lawrenceville, Va.; N. C. State, B.S.F., 1950.

Ralston, J. H., State College Sta., Raleigh, N. C.; W. Va. Univ., B.S.F., 1950.

Ray, P. L., Forest Asst., Duke School of Forestry, Durham, N. C.; Univ. of Minn., B.S.F., 1949.

Searcy, W. H., Service Forester, Va. Forest Service, Waverly, Va.; N. C. State, B.S.F., 1950.

Whitt, T. W., Service Forester, Va. Forest Service, Waverly, Va.; N. C. State, B.S.F., 1950.

Williams, W. D., Thr. Cruiser, Int. Paper Co., Georgetown, S. C.; Duke, B.A., (Botany), 1950; Duke, M.F., 1951.

Member Grade

Wood, R. A., Lbr. Mfg., Cons. Forester, Asheville, N. C.; N. C. State, B.S.F., 1933. Reinstatement.

Central States Section

Junior Grade

Cech, G. O., 2322 N. 77th Ave., Elmwood, Ill.; Mich. State, B.S.F., 1950.

Schmitt, R. H., Walnut, Ill.; Mich. State, B.S.F., 1950.

Venema, W. J., 1037A Birch Rd., E. Lansing, Mich.; Mich. State, B.S.F., 1948.

Wilson, R. M., Forester, U. S. Soil Cons. Service, Cambridge, Ohio; Univ. of Mich., B.S.F., 1934.

Columbia River Section

Junior Grade

Ballard, W. E., Jr., Forester, Pac. N. W. Forest and Range Exp. Sta., Portland, Oreg.; Univ. of Calif., B.S.F., 1935. Reinstatement.

Davison, A. T., Jr. Agric. Asst., Forest Insect Lab., Portland, Oreg.; Duke Univ., B.S., 1949; M.F., 1950.

Herstine, R. B., Forester, U. S. Bureau of Land Management, Coos Bay, Oreg.; Pa. State, B.S.F., 1949.

Gulf States Section

Junior Grade

Graham, E., 356 W. Northside Drive, Jackson, Miss.; La. State, B.S.F., 1950.

Hallberg, R. K., Forest Asst., Duke Forest, Durham, N. C.; Mich. State, B.S.F., 1949; Duke, M.F., 1950.

Hammarstrom, C., Pulpwood Buyer, Johns Manville, Natchez, Miss.; N. Y. State, B.S., 1935; M.F., 1936.

Leggett, A. A., State Forester, Miss. Forestry Comm., Jackson, Miss.

Pettey, J. R., Forester, Hood Mfg. Co., Jackson, Miss.; Univ. of the South, B.S., 1948; Yale, M.F., 1950.

Powell, D. H., 201 Clifton Ave., Natchez, Miss.; Univ. of Mich., B.S.F., 1950.

Raum, H. R., Forester, U.S.F.S., Lexington, Miss.; Iowa State, B.S.F., 1946.

Affiliate Grade

Welch, H. E., Area Forest Rgr., Miss. Forest Service, Jackson, Miss.

Wright, L. Q., Thr. Cruiser, Hazlehurst, Miss.

Inland Empire Section

Junior Grade

Huffman, P. W., Asst. Forester, Potlatch Forests, Inc., Lewiston, Idaho; Purdue, B.S.F., 1949.

Spencer, R. W., Thr. Marker, Dept. of Forestry, Coeur d'Alene, Idaho; Univ. of Idaho, B.S.F., 1949.

Intermountain Section

Junior Grade

Grimes, P. D., U.S.F.S., Garden Valley, Idaho; Iowa State, B.S.F., 1950.

Kentucky-Tennessee Section

Junior Grade

Grafton, C. F., Vice Pres., Sales Mgr., Chapman Chemical Co., Memphis, Tenn.; Univ. of Minn., B.S.F., 1937.

New York Section

Junior Grade

Dronzek, J. J., 264 Commerce St., Hawthorne, N. Y.; N. Y. State, B.S.F., 1950.

Ellis, C. W., 563 W. 181 St., N. Y., N. Y.; N. Y. State, B.S.F., 1948.

Johnson, G. L., Distributor, Elmira News Co., Ithaca, N. Y.; N. Y. State, B.S.F., 1950.

Payne, H. H., Purchasing Agent, Putnam-Hawley Bldg. Materials, Inc., Potsdam, N. Y.; N. Y. State, B.S.F., 1950.

Peterson, D. E., Field Asst., N. Y. State College of Forestry, Saranac Lake, N. Y.; N. Y. State, B.S.F., 1950.

Saunders, R. C., Box 315, Hyde Park, N. Y.; N. Y. State, B.S.F., 1950.

Northern California Section

Junior Grade

Patterson, H. E., Jr. Civil Engr., Calif. Div. of Forestry, Eureka, Calif.; Oregon State, B.S.F., 1949.

Seamount, D. T., 2024 Haste St., Berkeley, Calif.; Univ. of Calif., B.S.F., 1950.

Affiliate Grade

Oppenheimer, E. B., Office Mgr., Placerville Lbr. Co., Placerville, Calif.

Weselsky, J. W., Rt. 1, Nevada, Calif.

Northern Rocky Mountain Section

Junior Grade

Moore, W. R., Dist. Rgr., Lolo Nat'l. Forest, Missoula, Mont.

Siusher, E. C., Forester, U.S.F.S., Billings, Mont.; Univ. of Idaho, B.S.F., 1942.

Ozark Section

Junior Grade

Canter, E. H., Asst. County Ext. Agent, Univ. of Mo., Columbia, Mo.; Univ. of Mo., B.S.F., 1949.

Wilson, J. S., Field Asst., Int. Paper Co., Nashville, Ark.; La. State, B.S.F., 1949. Reinstatement.

Puget Sound Section

Junior Grade

Bevan, J. S., 1133 33rd Ave., N., Seattle, Wash.; Univ. of Wash., B.S.F., 1950.

Dickinson, F. L., Dist. Rgr., Olympic Nat'l. Park, Port Angeles, Wash.; Univ. of Wash., B.A., (Logging Engr.), 1937.

Rave, R. A., Forester, Lewis County Assessor, Chehalis, Wash.; Univ. of Wash., B.S.F., 1950.

Southeastern Section

Junior Grade

Anderson, R. F., Asst. Prof., Univ. of Ga., Athens, Ga.; Univ. of Minn., B.S.F., 1938; M.S., 1941. Reinstatement.

Calhoun, J. C., Asst. Mgr., Hudson Pulp and Paper Co., Palatka, Fla.; Univ. of Ga., B.S.F., 1942. Reinstatement.

Cox, R. L., County Forest Rgr., Ga. Forestry Comm., Edison, Ga.; Univ. of Ga., B.S.F., 1949.

Einspahr, D. W., Tech. Asst., Gamble Bros., Montgomery, Ala.; Iowa State, B.S.F., 1949; M.S., 1950.

Hicks, N. M., Foreman, Asplund Tree Expert Co., Atlanta, Ga.; N. C. State, B.S.F., 1950.

Rogers, J. W., Rt. 1, Arcadia, Fla.; Univ. of Fla., B.S.F., 1950.

Tucker, J. J., Dist. Supt., Int. Paper Co., Albany, Ga.; Univ. of Fla., B.S.A., 1950. (Affiliate 1948.)

Southern California Section

Junior Grade

Norman, R. H., 2123 Norwalk Ave., Los Angeles, Calif.; Oregon State, B.S.F., 1947.

Upper Mississippi Valley Section

Junior Grade

Gallaher, W. B., Forestry Aide, U.S.F.S., Fayette, Iowa; Iowa State, B.S.F., 1949.

Sanderson, W. J., Farm Forester, Div. of Forestry, Park Rapids, Minn.; Univ. of Minn., B.S.F., 1949.

Stokes, J. M., State Farm Forester, Iowa State Cons. Comm., Des Moines, Iowa; Iowa State, B.S.F., 1950.

Vandershule, T. D., 912 Pammel Court, Ames, Iowa; Iowa State, B.S.F., 1950.

Member Grade

Runkel, S. T., Dist. Cons., U. S. Soil Cons. Service, Ottumwa, Iowa; Iowa State, B.S.F., 1950. (Junior 1943R50.)

Foreign

Junior Grade

Ritchey, W. A., Div. Supt., Firestone Plantations Co., Liberia, W. Africa; Pa. State, B.S.F., 1950.

Candidates Elected

The following persons were elected to the indicated grades of membership by the Council on November 1, 1950.

Junior Grade

Allen, H. P.
Anderson, G. L.
Barden, C. F.
Batson, J. O.
Beltzer, C. E., Jr.
Bottke, E. A. (re)
Campbell, E. R.
Campbell, P. O.
Cann, J. J.
Caroline, C. J.
Carter, R. T.
Church, C. M.
Cleator, F. W. (re)
Coner, F. G., Jr.
Corn, E. F.
Edwards, A. C.
Erwin, H. K., Jr.
Farr, M. W.
Gross, R. W.
Hayford, C. G.
Hegtand, A. W.
Higinbotham, D. D.
Holt, G. G.
Ingram, D. O.
Jensen, E. P.
Lewis, W. I.
Locke, W. J.
Lukkarila, R. W.
Martin, J. R.
McCloskey, L. F.
McCormack, H. E.
McDonald, C. A.
Moon, E. C.
Moore, L. J.
Perry, E. L.
Proud, O. R.
Richardson, J. H.
Rowley, M. L.
Salt, A. A.
Slade, R. S.
Steinbrenner, E. C.
Stickney, R. A.
Strahan, L. C.
Strong, O. B.
Summerly, J. J.
Thigpen, D.
Thornton, P. L.
Toton, W. T.
Turinski, C.
Verbeek, A. R.
Walker, R. S.
Warner, P. W.
Wehking, E. F.
Wylie, J. E.

Member Grade

Berg, A. B.
Godfrey, H. W.
Handy, J. E.
Indoe, C. F.
Korte, K. H.
Lauterbach, P. G.
Smith, Z. G.
Tyrax, M. C.

Affiliate Grade

Earnest, J. T.
Guice, W.
Hopia, B.
Smith, F. W.
Touchstone, J. H.

Corresponding Grade

Wijkstrom, S.

New Members and Advancements

The new members and members who have been advanced in grade who are listed below are eligible for participation in the activities of the Society of American Foresters, including the meetings and projects of Sections, Chapters, Divisions, and Committees. They have submitted their applications for membership, properly endorsed, and have been declared eligible by the Council. By accepting election, these members have indicated their desire to assist the Society in the fulfillment of its objectives.

Allegheny Section

Junior Grade

Baum, J. V., 448 S. 4th St., Colwyn, Pa.
Conlin, R. A., 911 Westminster Ave., Hillside, N. J.
Elsburg, W. M., U.S.F.S., Laurel, Md.
Foley, R. P., Sutton, W. Va.
Kolb, W. D., 443 Park St., Morgantown, W. Va.
Neupauer, T. W., 1347 Louisa St., Williamsport, Pa.
Pike, C. C., 905 Overlook Way, S. Charleston, W. Va.
Porter, J. A., 94 C. St., Keyser, W. Va.
Porterfield, R. B., 137 Buehner Drive, Pittsburgh, Pa.
Ropeik, B. H., 59 Elmhurst Ave., Trenton, N. J.
Tennant, K. E., Fairview, W. Va.
Trygar, R. W., 495 State St., Perth Amboy, N. J.
Vande Linde, F., Danville, W. Va.

Member Grade

Ehrhart, E. O., Johnsonburg, Pa.

Appalachian Section

Junior Grade

Biddix, F. W., Jr., Spruce Pine, N. C.
Butler, A. P., Jr., Tryon, N. C.
Carroll, K. L., Duke Univ., Durham, N. C.
Dallas, H. G., Jr., Carolina Power and Light Co., Raleigh, N. C.
Dowdell, S. A., III, 1703 High St., New Bern, N. C.
Green, H. J., Smyrna Rd., Whiteville, N. C.
Hawkins, W. T., Kingstree, S. C.
Newman, W. P., Murphy, N. C.
Powell, L. W., 1419 Eighth St., Durham, N. C.
Rankin, J. R., 2718 Clark Ave., Raleigh, N. C.
Smith, B. F., 903 W. Club Blvd., Durham, N. C.
Speers, C. F., 78 Larchmond Rd., Asheville, N. C.
Spivey, J. F., Jr., State College Sta., Raleigh, N. C.
Stanley, L. S., Greenville, S. C.
Todd, D. P., 305 Sumter St., Charleston, S. C.

Central Rocky Mountain Section

Junior Grade

Fifield, C. E., Box 309, Aspen, Colo.
Slater, J. P., Jr., 2537 S. 33rd St., Omaha, Nebr.

Central States Section

Junior Grade

Auman, D. I., R.R. #1, Lisbon, Ohio
Coe, A., Box 67, Otter Lake, Mich.
Deane, J. A., 208 N. First St., Boonville, Ind.
Every, R. B., 985 Porter Rd., Milford, Mich.
Griffith, R. F., 807 N. Division St., Harvard, Ill.
Grmenec, C. J., 2604 Gehrum Lane, Cincinnati, Ohio
Hartwick, R. A., Rt. #1, Bannister, Mich.
Kelley, R. J., Albert E. Sleeper State Park, Caseville, Mich.
Knudson, L. L., Ohio Agric. Exp. Sta., Wooster, Ohio
McGuire, D. H., Jr., 1404 S. Gerrard Drive, Indianapolis, Ind.
Muschler, A. F., 615 Oswego St., Ann Arbor, Mich.
Nelson, R. A., 314 Berkeley Rd., Indianapolis 8, Ind.
Nielsen, M. C., 13661 Castleton Ave., Detroit 27, Mich.

Bardon, J. D., 2114 Moore St., Lafayette, Ind.
Benedict, 300 Le Roy, Clawson, Mich.
Bade, W. B., 508 Main St., East Jordan, Mich.
Swanson, 364 N. Commonwealth Ave., Elgin, Ill.
Ursic, S. J., Dixon Springs Exp. Sta., Robbs, Ill.
Watt, J. C., Box 177, Jerseyville, Ill.
Winter, A. V., Jr., 1314 Gilbert Ave., Downers Grove, Ill.

Associate Grade

Gilles, B., Rev., St. Meinrad Abbey, St. Meinrad, Ind.

Columbia River Section

Junior Grade

Bagley, L. J., Box 96, Myrtle Point, Oreg.
Berry, W. R., Box 84, Veneta, Oreg.
Denison, J. M., 706 Hawthorne Ave., Grants Pass, Oreg.
Fink, C. R., U.S.F.S., Estacada, Oreg.
Flink, C. F., Ochoco National Forest Burns, Oreg.
Griffin, J. B., 203 N. Ivy St., Medford, Oreg.
Hicks, W. S., Glide Rgr. Sta., Glide, Oreg.
Hills, R. O., 976 Kalmia St., Junction City, Oreg.
Howell, W. H., Jr., 808 N. 11th St., Corvallis, Oreg.
Jimerson, J. R., P. O. Box 186, Klamath Falls, Oreg.
Knight, W. R., Myrtle Point, Oreg.
Lorello, J. J., Pine, Oreg.
Marl, R. E., 8825 N. Chautauqua, Portland, Oreg.
O'Neill, D. H., Box 400, Roseburg, Oreg.
Ring, R. L., Jr., 809 W. Central, Coos Bay, Oreg.
Trotter, S. C., Box 591 Roseburg, Oreg.
Unterreiner, D. E., Box 368, Glendale, Oreg.

Member Grade

Hann, J. H., 565 Judson St., Salem, Oreg.

Gulf States Section

Junior Grade

Adkins, F. E., Box 61, Pachuta, Miss.
Bowling, D. R., Box 61, Pachuta, Miss.
Briscoe, C. B., Jr., Box 217, Shelly Island, La.
Burnham, H. M., Box 358, Good Pine, La.
Estes, L. F., 805 Poplar St., Grenada, Miss.
Flanagan, C. M., Tupelo, Miss.
Garofalo, J. J., Box 712, Amite, La.
Keither, T. D., Springhill, La.
Loeffler, J. R., La. State Univ., Baton Rouge, La.
Querin, H. M., U. S. Army, Fort Hood, Tex.
Simmons, L., Alcorn College, Alcorn, Miss.

Inland Empire Section

Junior Grade

Battin, C. R., Box 1445, Lewiston, Idaho.
Berger, C. G., Headquarters, Idaho.
Berntsen, C. M., Box 339, Moscow, Idaho.
Frazier, G. D., 1305 10th Ave., Lewiston, Idaho.
Larsen, L. H., % Milo Spicy, Kamiah, Idaho.
Lee, G. E., St. Maries, Idaho.
Ohlson, V., % Pierce Rgr. Sta., Pierce, Idaho.
Scribner, W. A., 701 East Third, Moscow, Idaho.
Ventshnick, J. C., W. 6th Village, Moscow, Idaho.
Williams, E. L., 735 E. 8th St., Moscow, Idaho.

Intermountain Section

Junior Grade

Cleaveland, E. C., 604½ 1st St., Emmett, Idaho.
Clyde, J. F., 312 Mountain St., Carson City, Nev.
Derts, N. A., Box 193, Circleville, Utah.
Horton, L. E., Box 146, Spanish Fork, Utah.
Jackson, H. R., 3024 Adams Ave., Ogden, Utah.
Seaman, D. D., 141 S. 200th W. St., Cedar City, Utah.
Youngblood, G. B., Council, Idaho.

Kentucky-Tennessee Section

Junior Grade

Dehls, R. R., Waverly Hotel Apts., Waverly, Tenn.
Olander, D., 108 E. Kingston Ave., Louisville, Ky.
Ramsay, J. C., 110 Fonville St., Martin, Tenn.

New England Section

Junior Grade

Arader, H. E., Jr., 64 Hoyt's Hills, Bethel, Conn.
Blaisdell, G. M., Jr., 114 Franklin St., Rumford, Me.
Gratkowski, H. J., Box 15, Woodmont, Conn.
Horner, C. E., 34 Greenwood Rd., Wellesley Hills, Mass.
Masters, H. M., Round Pond, Me.
Natti, T., 1142 Washington St., Gloucester, Mass.
Nelson, F. B., 28 Pleasant View St., Bangor, Me.

New York Section

Junior Grade

Foster, R. W., Pack Forest, Warrensburg, N. Y.
Heavrin, C. A., Syracuse Univ., Syracuse, N. Y.
Kurnmeyer, E. J., 112 James St., Boonville, N. Y.
Nagy, W., Greig, N. Y.
Nellis, J. W., 35 Virginia Ave., Rochester, N. Y.

Northern California Section

Junior Grade

Barnickel, H. J., U.S.F.S., Hathaway Pines, Calif.
Bruton, Q. H., 931 Fell St., Redding, Calif.
Callahan, D. T., 2301 Durant Ave., Berkeley, Calif.
Cusod, B. C., U.S.F.S., Challenge, Calif.
Graham, E. D., 751 S. 52nd, Richmond, Calif.
Graham, W. C., Jr., Crannell, Calif.
Herbert, F. R., 3725 42nd St., Sacramento, Calif.
MacPherson, W. R., Star Route, Eureka, Calif.
Merritt, R. A., 123 26th St., Merced, Calif.
Merryman, S. G., % Forest Insect Lab., Berkeley, Calif.
Miller, H., Jr., Gen. Dev., Cloverdale, Calif.
Scathe, W. H., U.S.F.S., Greenville, Calif.
Spencer, R., 5117 W. 116th St., Los Angeles, Calif.
Winters, W., 709 Santa Ynez Way, Sacramento, Calif.

Member Grade

Baer, H., Crannell, Calif.

Northern Rocky Mountain Section

Junior Grade

Dockins, W. C., U.S.F.S., Deerlodge, Mont.
Evans, W. L., Yellowstone Park, Wyo.
Gashwiler, R. N., 245½ Connell Ave., Missoula, Mont.
Merkle, J. R., Moskee Rt., Sundance, Wyo.
Sheldon, L. C., Rt. 3, Missoula, Mont.
Stevens, D. R., Yellowstone Park, Wyo.
York, O. E., 2108 Hilda Ave., Missoula, Mont.

Ozark Section

Junior Grade

Bender, F. J., Branson, Mo.
Cole, D. E., 210 S. Cumberland St., Sheridan, Ark.
DeWitt, W. A., % Southern Lbr. Co., Warren, Ark.
Engelhard, R. J., U. S. Army, Fort Sill, Okla.
Lipscomb, R. B., 826 Normal, Springfield, Mo.
Pride, T. J., Fordyce Lbr. Co., Fordyce, Ark.
Whitt, F. B., Dist. Forester, Ellington, Mo.

Member Grade

Anderson, L. M., Box 1940, Little Rock, Ark.

Puget Sound Section

Junior Grade

Host, J. R., 10805 N. E. 55th Place, Kirkland, Wash.
Johnson, V. J., Div. of Land Planning, Anchorage, Alaska
Jungster, H., 3302 E. Mercer St., Seattle 2, Wash.
Leaf, A. L., 3534 46th N.E., Seattle, Wash.
Little, G. R., Naselle Rgr. Sta., Naselle, Wash.
Schlick, W. T., Colville Indian Agency, Nespelem, Wash.
Smith, J. H. G., 761 Pleasant St., Kamloops, B. C., Can.

Southeastern Section

Junior Grade

Austin, C. F., 108 N.W. 3rd Ave., Gainesville, Fla.
Cook, F. M., 416 W. Cervantes, Pensacola, Fla.
Hoard, T. E., Star Route, Carrabelle, Fla.
Johnson, T. L., Jr., Stockton, Ga.
Mathews, J. B., Co. Agents Office, Talladega, Ala.
Meigs, H. K., Box 247, Carrollton, Ala.
Mikell, J. K., 800 W. Lafayette St., Marianna, Fla.
Mobley, H. E., Jr., 5021½ E. Selma Ave., Tampa, Fla.
Nickens, R., Jr., Madison, Ga.
Olive, C. L., Jr., 1310 Sherrod Ave., Florence, Ala.
Orwig, H. S., 210 S. 8th Ave., Wauchula, Fla.
Vetter, W. T., 2120 N. W. 24th St., Miami, Fla.

Welch, J. E., 225 Peachtree Rd., Gainesville, Ga.
Yow, V., Abraham Baldwin Agric. College, Tifton, Ga.

Member Grade

Woodman, J. E., Barnett Bank Bldg., Jacksonville, Fla.

Southern California Section

Junior Grade

Mounts, J., Arroyo Seco Rgr. Sta., Pasadena, Calif.
Roget, E. L., 10744 S. Bonavista Lane, Whittier, Calif.

Southwestern Section

Junior Grade

Jones, F. M., Box 412, Magdalena, N. Mex.

Upper Mississippi Valley Section

Junior Grade

Barnes, C. C., 202 S. Russell, Ames, Iowa
Cover, M. A., 618 Wall St., Mankato, Minn.
La Mois, L. M., Akeley, Minn.
Lundberg, L. E., Gheen, Minn.
Roeber, P. C., 293 Aurora Ave., St. Paul, Minn.
Sandberg, D. L., 2113 Como Ave., St. Paul, Minn.
Skok, R. A., 1654 Eleanor Ave., St. Paul, Minn.
Sullivan, G. J., 4739 Central Ave., Minneapolis, Minn.

Member Grade

Pierce, D. E., 31 Fourteenth St., Chisholm, Minn.

Washington Section

Junior Grade

Ottenbach, P. J., 311 Tulip Ave., Takoma Park, Md.

Wisconsin-Upper Michigan Section

Junior Grade

Blomquist, T. W., Griffith State Nursery, Wisconsin Rapids, Wis.
Horn, A. E., Jr., 4242 N. 18th St., Milwaukee, Wis.
Lindholm, V. V., 2352 N. 35th St., Milwaukee, Wis.
Mendel, G., 1038 S. 26th St., Milwaukee, Wis.
Pearson, R. A., 48 N. Main, Hartford, Wis.
Strothmann, R. O., 2320 E. Rusk Ave., Milwaukee, Wis.
Thorne, H. W., Wisconsin Cons. Dept., Hayward, Wis.

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Forestry News

National Forests Timber Sales Set New Record

More timber was cut on national forests during the first quarter of fiscal year 1951 than in any other quarter period on record. The increased cut brought timber sale receipts to an all-time high for any one quarter.

Between July 1 and September 30, 1,483,616,000 board feet of timber were taken from the national forests, a 39 percent increase over the amount cut during the same period in 1949. The highest previous record was in the corresponding quarter of 1948 when 1.3 billion board feet were cut.

During the 3-month period ending September 30, 1950, the Forest Service collected $13,313,293 from the sale of timber as compared with $8,842,397 taken in for the same period in 1949. The average value of timber cut in the first quarter of fiscal year 1950 showed an increase of only 65 cents per thousand board feet over that of the first quarter of fiscal year 1949.

Forestry College Collects Data On 2½ Million Adirondack Acres

Field data on two and one half million acres of public and private forest lands in the Adirondacks have been collected in six months by the State University of New York, College of Forestry, Syracuse. This is 25 percent of an intensive, two-year study begun last April.

The study will show location, kind of forest, amount of merchantable wood, and quality and rate of growth. When completed, it will cover 6 million acres and be the most intensive of its kind in the country.

The College of Forestry is making the Adirondack-Catskill survey under a special appropriation by the New York State legislature, at the request of the Board of Equalization and Assessment.

The board plans to provide town assessors with forest property maps showing the college's data. Allen W. Bratton, the board's chief forester, said that the information will be used in working with local assessors to help them arrive at standard procedures for assessing forest- and forest lands.

Comprehensive Plan for Rogue River Basin

Investigations in the Rogue River Basin, Oregon, to supplement those substantially completed by the Bureau of Reclamation have been commissioned, looking toward early preparation of a comprehensive plan for balanced multi-purpose development and conservation of the natural resources of the basin.

"While we have fairly complete information on irrigation and power aspects of a comprehensive plan," Interior Secretary Oscar L. Chapman points out, "we do not have equally detailed information on the scenic, recreation, and fish and wildlife aspects."

The following specific studies were ordered by the Secretary:

1. Investigation of the fish in the Rogue River and its tributaries through at least a full fish cycle by the Fish and Wildlife Service, to be assisted by the Oregon State Game Commission.

2. Evaluation of the scenic and recreational resources of the region, a large portion of which are on public lands, to be carried out by the National Park Service and the Bureau of Land Management.

3. Assembly of basic water and geologic data and analyses of minerals potentialities by the Geological Survey and Bureau of Mines.

4. Coordination of these investigations by the Pacific Northwest Field Committee, composed of the regional heads of the Interior agencies in the Pacific Northwest, looking toward development of a truly comprehensive plan.

While these studies are going on, the Secretary directed that necessary steps be taken to assure the preservation of the scenic and recreational values in the headwaters and downstream sections of the basin and the proper management of the public lands with this end in view.

An intensive study by the Bureau of Reclamation has already provided specific information on the acres of land to be irrigated, the number of kilowatts of hydro power which can be developed, the flood control possibilities, and the total cost of such development. Parallel information, however, is not yet available on the fishery and recreational values, the portions of the fish runs that might be blocked by dam construction, and the measures required to mitigate fish losses.

Because of the great interest of state and local governments and other groups in the Rogue River, Interior agencies have been directed to work closely with them. When a feasible plan is available, it will be submitted to the states and federal departments concerned for comment, and transmitted with such comments to the Congress for authorization.

Federal Timber Unit Appealed

Appeal to the Secretary of Agriculture against the establishment of the Lakeview, Oreg., federal sustained-yield timber unit has been made by Congressman Engle of California. The timber unit, which is a part of the Fremont National Forest with headquarters at Lakeview, was established on October 10, 1950. The appeal, according to the Forest Service, renders the October decision of the Forest Service non-effective for the present, and final establishment will be dependent upon the nature of the Secretary of Agriculture's decision. No date has been set for a hearing on the appeal.

The purpose of the contested Lakeview federal unit is to stabilize the economy of Lakeview and Paisley. The Forest Service has determined that these two communities are primarily dependent upon the federally owned timber. In accordance with the terms of the policy statement which governs the proposed unit, national forest timber sold from it would be required to be manufactured within the Lakeview and Paisley communities. Aside from the restrictions limiting the location of its manufacture, the federal timber would be sold competitively to the high bidder as is customary in transactions involving the sale of national forest stumpage.

The contested Lakeview federal sustained-yield unit is comprised of approximately 19,000 acres of national forest land in Klamath County and 170,000 acres of national forest land in western Lake County. Over 2½ billion board feet of merchantable national forest timber is involved. Under its policy of sustained-yield management, the Forest Service would allow 50 million board feet to be harvested from the unit each year.

Scientists to Register

Within the next few months, approximately 150,000 American scientists and technologists will be asked to participate in one of the most comprehensive registrations of scientific personnel yet attempted by the government. Final plans have been completed for this operation by the National Scientific Register, sponsored by the National Security Resources Board, and administered by the Office of Education, Federal Security Agency. The registration will include qualified scientists in the natural and physical sciences, and will be accomplished through the direct assistance of the principal professional and scientific societies, including the Society of American Foresters. The purpose of the registration is to provide urgently needed information on the country's supply of technological personnel in the many scientific fields—information needed for both immediate and long-range mobilization planning.

Provision has been made for such a register in legislation creating the National Science Foundation. However, because of the international situation early in 1950, the NSRB decided that this important function could not be delayed longer, and that some interim action should be taken pending the creating of the NSF. Accordingly, the National Scientific Register was established in the Office of Education in the summer of 1950.

The scientific fields to be included in the present registration are as follows: physics, chemistry, the biological sciences, geology, geophysics, meteorology, astronomy, mathematics, and crystallography. Registration will not be made in the engineering fields at this time since the recent study of American engineers, sponsored by the Office of Naval Research and completed under the direction of the Engineers Joint Council, has been made a part of the National Scientific Register. When registrations in the fields of science just named have been completed, it is anticipated that a follow-up study will be made in the fields of engineering to complete the coverage.

Forester Joins Philippine Firm

Perry O. Donaldson, consulting forester of Tacoma, Wash., has been named forest engineer for the Basilan Lumber Company, Basilan Island. The company is engaged in the local manufacture and export of various Philippine hardwoods.

Frank Murphey Retires

Frank T. Murphey, Pennsylvania extension forester, retired October 31 after a career devoted to development of better woodlot programs, mostly on Pennsylvania farms.

Except for two years in U. S. Army service in France during World War I, his whole time after graduating from Penn State in 1914 was spent in forestry work. Even during the war his work was in timber supply as a member of the 20th Engineers. In 1930 he earned a master of forestry degree at Yale.

He joined the Pennsylvania Extension Service staff of the college in 1923.

New Chemical Is Threat To Mesquite

Encouraging evidence that aerial sprays 2,4,5-T can be used in northern Texas to kill mesquite, is reported by the U. S. Department of Agriculture and the Texas Experiment Station.

As a preliminary step toward solving the gigantic problem of brush control on several million acres in the Southwest, it offers, for the first time, a mass method for fighting mesquite in the less arid sections of the range country at comparatively low cost. It is believed also to hold clues to control methods in other environmental conditions and for other species of brush.

The experiments with mesquite at Spur, Texas, show that it can be killed by aerial sprays of 2,4,5-T applied late in May when the brush is in vigorous growth. The treatment is similar to that in which 2,4-D is now used to control sagebrush on the grasslands of the Southern Great Plains.

For mesquite in west Texas two-thirds pound of the ester form of 2,4,5-T in 5 gallons of 20 percent oil emulsion was used. Cost of this treatment for large scale operations is estimated at $3 an acre. The kill is 98 percent for the tops of the brush and more than 50 percent of the roots. The chemical has given 65 percent kill when applied as a ground spray to mesquite foliage and up to 90 percent kill when used to treat the cut surfaces of stumps. Spray applications to the lower 12 inches of the trunk have killed both tops and roots.

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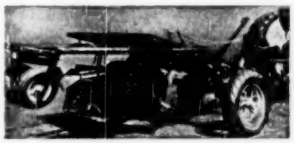

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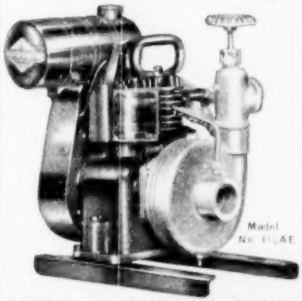

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Insect and Plant Disease Control Administrator Dies

Erle G. Brewer, leader of the U. S. Department of Agriculture's Division of Japanese Beetle Control, and responsible for the department's regulatory activities against the Japanese beetle, Dutch elm disease, and the gypsy and brown-tailed moths, died October 20 in East Orange, N. J. following a long illness. Wm. Middleton has been named acting leader of the division. Mr. Brewer had been in the insect control field since 1906, and in the employ of the department since 1920, almost entirely in responsible supervisory positions. He was born December 2, 1887, in Lynn, Mass., where he received his early education. He began his life work against insect pests in 1906 as a scout for gypsy moth for the State of Massachusetts. In 1910, he was appointed superintendent of moth work of the town of Hamilton, Mass., and in 1911, superintendent of moth work for Massachusetts, a position he held until 1919 when he entered federal employment in the Bureau of Entomology and Plant Quarantine.

Philippine College Receives Forestry Books Through Care

The war devastated College of Forestry of the University of the Philippines has received $146 worth of new reference and textbooks sent by American forestry students through the CARE-UNESCO Book Fund, in cooperation with the American Forestry Association.

Donors of the gift, which comprised 29 of the latest and best American volumes on forestry and conservation, were the students of the College of Forestry, University of Washington, Seattle; the Forestry Club at Iowa State College of Agriculture and Mechanical Arts, Ames; and Richard C. Hebling, 1718 N. Major St., Chicago.

Record Stumpage Price

The winning bid of $44.10 per thousand board feet for 168 million board feet of timber stumpage located north of the Grand Canyon in Arizona on the Kaibab National Forest has set an all-time price record for timber sold from national forests in the Southwest.

Whiting Brothers of Holbrook, Ariz., one of four bidders, were awarded the contract. Timber will be reappraised periodically, but no reduction below bid rates can become effective until at least 15 million board feet have been cut.

The bid of $44.10 per thousand board feet includes a deposit of 60 cents to be used by the Forest Service to improve the timber stand after logging operations.

The stand consists of approximately 95 percent ponderosa pine, with the remaining 5 percent being Douglas-fir, white fir, and spruce.

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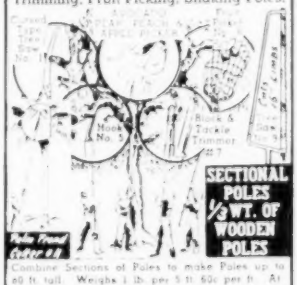
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Furniture Short Course at N. C.

Twenty-four representatives of furniture manufacturers in four southern states attended October 16 to 21, the first furniture finishing short course of its kind ever offered, according to Roy M. Carter, professor of wood technology, School of Forestry, North Carolina State College. The instruction was promoted and sponsored by James T. Ryan, executive vice-president, Southern Furniture Manufacturers Association and co-sponsored by the National Paint, Varnish and Lacquer Manufacturers' Association.

Instruction was planned and conducted by Professor Carter and E. Sigurd Johnson, associate professor, furniture manufacturing and management, N. C. State College, with the help of the college extension division and R. I. Quigley, vice-president of the Lilly Company, High Point, N. C. Representatives of the paint and varnish manufacturers cooperated by conducting some of the instruction and by making actual demonstrations at the plant of the Marietta Paint and Color Company and the plant of the Lilly Company.

National Forest Burn Doubles

Because of severe fire conditions in California and the Southwest, the acreage burned this year on national forests has nearly doubled that of a year ago.

By September 30, 1950, 324,414 acres of land inside the national forests had suffered fire losses as compared with 171,751 acres burned during the first nine months of 1949. The five-year average acreage burned for the same period was 192,621.

The number of fires on national forests, on the other hand, dropped for the 9-month period from 9,962 in 1949 to 8,649 in 1950. The 1945-49 average for the same nine months is 9,344 forest fires.

Carl A. Gustafson, chief of fire control, in reviewing the fire records for the 9-month period, reported that California national forests suffered the most severe fire season in 25 years. Although the number of fires dropped from 1,959 in 1949 to 1,816 in 1950, the acreage burned almost quadrupled —jumping from 57,607 in 1949 to 225,498 in 1950. The 5-year average for California is 1,369 fires with a burned area of 54,616 acres.

Arizona and New Mexico, Forest Service Region 3, also experienced one of their worst spring fire seasons. The number of fires showed an increase of only 23 over the 1,594 reported last year, but the acreage burned rose from 3,263 in 1949 to 32,203 in 1950. The average area burned in the 1945-49 period for these states is 19,616 acres.

Wohlenberg Named Masonite Vice President

The board of directors of Masonite Corporation has elected E. T. F. Wohlenberg, general manager of the company's new hardboard plant at Ukiah, Calif., to a vice presidency in the company. Before joining the company in 1948, he had had more than 30 years' experience in west coast lumbering and forest conservation activities with the Western Forestry and Conservation Association, as a consulting forest engineer, general manager for a large lumber company in Oregon, forester in charge of private forestry work with the U. S. Forest Service, and valuation engineer for the timber section of the U. S. Treasury Department.

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Commerce Monthly Bulletin Summarizes Lumber Reports

The *Lumber, Plywood, and Allied Products Industry Report* published quarterly by the U. S. Department of Commerce brings together basic data on production, stocks, shipments, new orders, and unfilled orders.

In the August 1950 number of the report is contained the first annual statistical supplement with data for many items recorded for the years 1929 through 1949, and in the case of hardwood flooring production, from 1907 through 1949.

This quarterly service from the Department of Commerce is available for $1 per year through the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Forest Service Regional Engineer Selected

Howard R. Jones, assistant chief engineer in the Washington office of the Forest Service, has been named regional engineer for the Northern Region of the Service with headquarters at Missoula, Mont. He succeeds Fred E. Thieme as head of national forest engineering activities in Montana, northern Idaho, northeastern Washington, and northwestern South Dakota. Mr. Thieme will retire December 31, 1950, after 39 years' service in the region.

Mr. Jones was born in Missoula and studied forestry at the University of Montana. During 1919 and 1920 he worked in Missoula for the U. S. Bureau of Public Roads and for private firms. He received his B.S. degree in civil engineering from the University of Washington in 1923. Before entering the Forest Service in 1930 he was employed by the City of Seattle, the Pioneer Sand and Gravel Company of Seattle, and the Weyerhaeuser Timber Company.

Louisiana Association Meets

State sponsorship of the National Tree Farms Program by the Louisiana Forestry Association was approved at a meeting of the group's Executive Committee November 1.

Lloyd P. Blackwell, Ruston, director of the forestry department at Louisiana Polytechnic Institute, was named state chairman of the movement. It will be organized and developed by the association in cooperation with the State Forestry Commission.

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Southern Agricultural Workers To Meet in February

The 48th annual meeting of the Association of Southern Agricultural Workers will be held in Memphis, Tenn., February 5, 6, and 7, 1950. Headquarters will be at the Hotel Peabody, with general sessions being held there from 11 a.m. to 12:30 p.m. each day. Because of the large anticipated attendance, the various section meetings will be held as follows: Forestry, Agricultural Engineers, Agricultural Editors, Entomology, Poultry, and Home Economics in the Hotel Peabody; Agronomy, Animal Husbandry, and Plant Physiology in the Hotel King Cotton; Agricultural Economics and Rural Sociology, Dairy, Marketing, Cotton Conference, and Weed Conference in the Hotel Claridge.

Park Visitors Exceed Previous Records

More than 32,780,000 people — a new record—visited national parks monuments, and other areas administered by the National Park Service during the travel year which ended last September 30.

Director Newton B. Drury of the Park Service reports that the new record was achieved despite the transfer of the Lake Texoma Recreational Area, which had nearly 2 million visitors during 9 months of the 1949 travel year, to Corps of Army Engineers administration.

The 1950 record of 32,782,238 visitors compares with 31,864,180 for the previous year, the highest number recorded up to that time. For the areas on which this year's totals are based, however (omitting Lake Texoma), the comparable figure for 1949 was 29,883,304, so that the 1950 total is nearly 3 million higher than 1949.

The Lincoln Memorial in the National Capital led all the areas administered by the National Park Service, with 2,042,632 visitors. In five of the national parks, more than a million were recorded. These were Great Smoky Mountains, in Tennessee and North Carolina, 1,774,265; Shenandoah, in Virginia, 1,292,113; Rocky Mountain, Colorado, 1,265,988; Platt, in Oklahoma, 1,165,043; and Yellowstone, in Wyoming, Montana, and Idaho, 1,109,926. Of these only Yellowstone showed a decrease, from 1,133,516. Reports of overcrowded facilities, as well as unfavorable weather during the period of heaviest travel, are believed to be principally responsible for this slight decrease.

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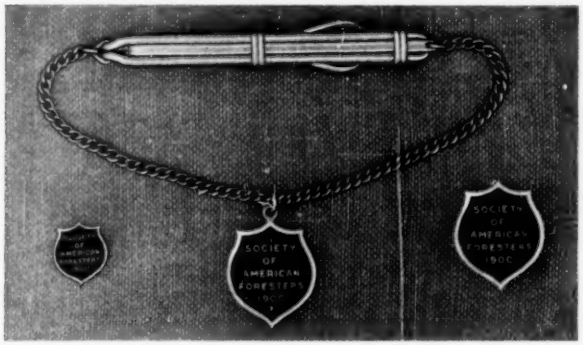

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Forester, 26, desires public relations job in Country. B.S.F., University of Idaho, 1948. M.F., University of Michigan, 1950. Two years public relations experience. Detailed information upon request. Box L, Journal of Forestry, Mills Building, Washington 6, D. C.

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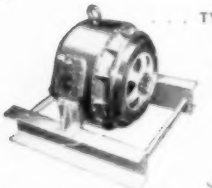

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